406
N m

THE

GEOLOGICAL MAGAZINE.

NEW SERIES.

DECADE III. VOL. X.

JANUARY—DECEMBER 1893.

ology

N H

THE

GEOLOGICAL MAGAZINE:

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCXLIII. TO CCCLIV.

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., V.P.G.S., F.Z.S., F.R.M.S.,

OF THE BRITISH MUSEUM OF NATURAL HISTORY;
VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY,
MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND NORWICH; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL HISTORY OF MOSCOW; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE MALACOLOGICAL SOCIETY OF BELGIUM.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., F.C.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., PRES.G.S., F.L.S., F.C.S.

AND

GEORGE J. HINDE, PH.D., V.P.G.S., &c.

NEW SERIES. DECADE III. VOL. X.

JANUARY—DECEMBER, 1893.

SMITHSONIAN INSTITUTION
143973
NATIONAL MUSEUM.

LONDON:
KEGAN PAUL, TRENCH, TRÜBNER & Co., LIMITED,
PATERNOSTER HOUSE, CHARING CROSS ROAD, W.C.
F. SAVY, 77, BOULEVART ST.-GERMAIN, PARIS.
1893.

HERTFORD:
PRINTED BY STEPHEN AUSTIN AND SONS.

LIST OF PLATES.

PLATE		TO FACE PAGE
I.	Portrait of Professor T. Rupert Jones, F.R.S., F.G.S., etc.	1
II.	A Gigantic horned Dinosaur, *Triceratops prorsus*, Marsh	41
*	Portrait of Sir Richard Owen, K.C.B., M.D., F.R.S. etc.	49
III.	*Myriolepis hibernicus*, Traquair, sp. nov.	54
IV.	*Palæosaccus Dawsoni*, Hinde, gen. et sp. nov.	56
V.	Sheared Limestones from Ilfracombe	100
VI.	*Ceratosaurus nasicornis*, Marsh	154
VII.	*Claosaurus annectens*, Marsh	155
VIII.	*Mastodon Americanus*, Cuvier	164
IX.	*Steneosaurus Baroni*, R. B. Newton	193
X.	Palæozoic Phyllopods, etc.	198
XI.	Portrait of Professor Joseph Prestwich, D.C.L., F.R.S., etc.	241
XII.	Abnormal forms of *Spirifera lineata*	249
XIII.	View of Barren Island, Bay of Bengal	289
XIV.	New Ostracoda from the Gault	345
XV.	Fossil Ostracoda from from S.W. Wyoming and Utah	385
*	Portrait of James William Davis, F.L.S., F.G.S., F.S.A.	427
XVI.	Cretaceous Pycnodonts	435
XVII.	Cretaceous Pycnodonts	487
XVIII.	Restoration of *Coryphodon hamatus*, Marsh	481
XIX.	Permian Estheriæ	529

* These portraits are not numbered, but the Binder is requested to insert them in the Volume to face the page indicated.—Edit. Geol. Mag.

LIST OF WOODCUTS.

PAGE

Cliff, Combe Martin Bay 4

" " " " 4

Folds in limestone quarry, Combe Martin Bay 5

Fold in flaggy beds, Ilfracombe 7

Section through Lantern Hill, Ilfracombe 7

Section, S.W. face of Capstone Point 7

Section through the Torres, Ilfracombe 7

Cleavage obliterating bedding in slaty beds 8

Map showing dispersion of Eskdale Granite 16

Page-map showing relations of Eskdale Drift to the Country Rocks 17

Cyclus Scotti, H. Woodw., sp. nov. 28

Cyclus Woodwardi, F. R. Cowper Reed, sp. nov. 64

Section of Har Dalam Cave 68

Phlyctænaspis Acadica, Whiteaves 148

Anchisaurus colurus, Marsh 150

"*Cryptozoë problematica*," Packard 203

Section illustrating quartz-schists in the Alps 207

Unstratified Boulder-clay with pebbles 218

Road-section at York-Town, Surrey 220

Granite and serpentine at the Lizard 221

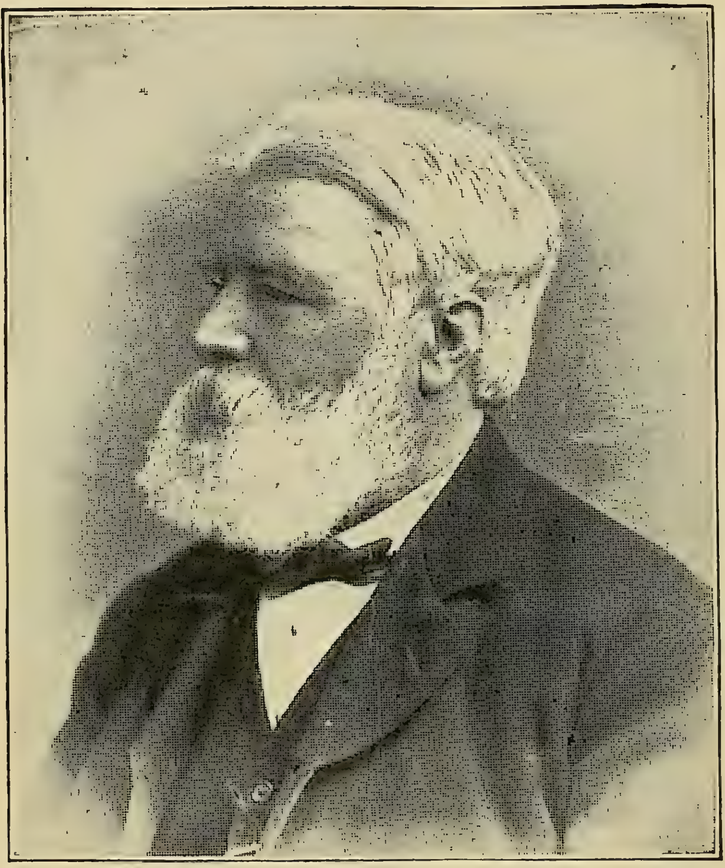
Drainage Area of Lake Zurich 222

Section across Limmat Valley at Zurich 222

"Crapaudine Locket" 248

Discites Hibernicus, Foord and Crick, sp. nov. 254

PAGE
Thickness of Marine Deposits 259
Tuscan Archipelago 273
Loch Broom Earthquake 294
South-West Cornwall Earthquakes 297
Map of India 310
Diagramatic section of the Southern Mass of Gneissic Rocks 311
Section of Ash from the summit of Rhobell-y-big 343
Chaman extension Railway, Quetta Earthquake 356
Earthquake Fissure 358
Distortion of Railway line by Earthquake 358
Cladodus rivipetrosi, Claypole 445
Engadine Lakes 453
Palæospondylus Gunni, Traquair 471
Skull and feet of *Coryphodon hamatus*, Marsh 483
Cranium and feet of *Dinoceras*, Marsh 486
Shells of *Anthracoptera* 540



Yours very truly
T. Rupt. Jones

Geological Magazine, Decade III. Vol. X. No. I. January, 1893.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. I.—JANUARY, 1893.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists. No. 7.

Professor Thomas Rupert Jones, F.R.S., F.G.S., etc.

(With a Portrait.)

THE commencement of the thirtieth year of the publication of the Geological Magazine appears to be an appropriate occasion to offer a short account of the life and work of one who for the first twelvemonths Edited, with Henry Woodward, this Journal, and has, ever since, been one of its most regular contributors.

Thomas Rupert Jones was born October 1st, 1819, at Wood Street, Cheapside, and is the son of John Jones, Silk Merchant and Silk Throwster, of London and Taunton, a descendant of the old Powys family of North Wales, and Rhoda Jones (*née* Burberry) of Coventry. He was educated at Foster's, at Taunton, and the Rev. John Allen's, at Ilminster. It was during his schooldays at Mr. Allen's that Rupert Jones was first attracted to a love for geology, by observing the Ammonites scattered plentifully about in the quarries of the Upper Lias at Ilminster. Curiously enough the late Mr. Charles Moore was also led to become an enthusiastic student of geology by seeing the same quarries and their fossils, as a schoolboy, about the same time. Later on, when apprenticed to Mr. Hugh Norris, Surgeon, at Taunton, Somerset, in 1835, he observed that the walls were built of Lias stone, and contained fossils. Here he read with interest "Parkinson's Organic Remains of a Former World," which appears to have exercised a powerful influence over his youthful mind. After the death of Mr. Norris he finished his apprenticeship with Dr. Joseph Bunny, of Newbury, Berks, in 1842.

After some years of medical and scientific education he was, in 1850, appointed Assistant-Secretary to the Geological Society of London; Lecturer on Geology at the Royal Military College, Sandhurst in 1858, was made Professor in 1862, and subsequently also appointed to the Staff College.

He was author of a "Monograph of the Cretaceous Entomostraca," in 1849; and of "The Tertiary Entomostraca of England," in 1856; and a Monograph of the Fossil *Estheriæ,*" 1862; he wrote the article "*Tunicata,*" in Todd's "Cyclopædia of Anatomy," 1850; and articles in Cassell's "Natural History," "Science for All," and the "Encyclopædic Dictionary." Prof. T. R. Jones is also author of numerous articles and memoirs on Geology, Palæontology, and Prehistoric Man, and especially on recent and fossil Entomostraca and Foraminifera, in the Quarterly Journal of the Geological Society, the Natural History Review, the Annals and Magazine of Natural History, the Geologist, the GEOLOGICAL MAGAZINE, the Proceedings of the Geologists' Association, and other periodicals.

He is joint author of the "Monograph of the Arctic and North-Atlantic Foraminifera," 1865; the "Foraminifera of the Abrohlos Bank," 1888; the "Foraminifera of the Crag," 1866; the "Nomenclature of the Foraminifera," in 15 Parts, 1859–72; of the "Micrographic Dictionary," 1874 and 1882; of a "Monograph of the Carboniferous *Cypridinadæ*," 1874 and 1884; of the "Palæozoic Phyllopoda," 1888–92; "Geology," Part I. Heads of Lectures, etc., 1870; and of numerous papers on Carboniferous and other Entomostraca. Professor Jones was the editor of the "Arctic Manual," issued by the Admiralty in 1875; and the editor and joint author of the "Reliquiæ Aquitanicæ," in 17 parts, 4to., 1865–75, pp. 530, with 90 plates; and of the second edition of "Dixon's Geology of Sussex," 1878.

He was formerly Examiner to the London University, the Victoria (Manchester) University, and the New Zealand University; and is now Examiner to the College of Preceptors; Assistant-Examiner to the Civil Service Commission, and to the Department of Science and Art. He was elected a Fellow of the Royal Society in 1872, and of the Geological Society of London in 1852, and is an Honorary Member of numerous scientific societies, both British and Foreign.

In presenting the Lyell Medal of the Geological Society to Prof. Rupert Jones, February 21, 1890, the President, Dr. W. T. Blanford, said: "There is unusual pleasure in presenting one of the chief awards in the gift of the Council to a geologist who has been so long and so honourably associated with the Geological Society as yourself, and the appropriateness of the award is not decreased by the circumstance that your official connection with the Society commenced when the great geologist, who founded this medal, was President. Since that time, now forty years ago, you have written much on various fossil organisms, but especially on the Entomostraca and Foraminifera, and in many cases, and especially amongst the Bivalved Crustaceans of the older rocks, it is largely to your researches that we are indebted for our present knowledge of these forms. You have also devoted much time and attention to the Geology of South Africa, and to bringing together the scattered information that we possess concerning the geology of that interesting region. I think that the Council have carried out the intentions of Sir Charles Lyell, and that they are justified in believing that, in his words, 'the Medallist has deserved well of the science.'"

Professor Rupert Jones was elected President of the Geologists' Association, filling that office from 7 February, 1879, to 4 February, 1881. He was a Vice-President of Section C (Geology) at the Meeting of the British Association at Montreal, August, 1884, the only occasion on which the Association visited one of our Colonies; he acted also at subsequent annual gatherings, and was President of the Geological Section at Cardiff in August, 1891. The list of his separate published papers exceeds one hundred, and he is joint author of nearly half as many more with Dr. Harvey B. Holl, F.G.S., Professor W. K. Parker, F.R.S., Dr. H. B. Brady, F.R.S., Mr. J. W. Kirkby, Dr. H. Woodward, F.R.S., Mr. Chas. Davies Sherborn, F.G.S., Dr. G. J. Hinde, V.P.G.S., and others.

From 1850 to 1865, Prof. Rupert Jones Edited the Quarterly Journal of the Geological Society, and, at the request of the Council, he undertook the editing of the latter half of vol. xlvi. (1890), left unfinished by the lamented death of Mr. W. S. Dallas.

Whether as Lecturer, Professor, Author, or Reviewer, Prof. T. Rupert Jones has always aimed at the advancement of geological science, and although never enjoying a liberal emolument for his professional services, he has never lost his enthusiasm, but laboured on for more than forty years, and is still full of energy and love for that science to which he has devoted his whole life. He has the satisfaction to know that although the pursuit of science is not so remunerative as other professions to which he might have turned his talents, he has nevertheless earned the warm esteem and regard of a very wide circle of friends and fellow-workers who admire his personal character and respect his worth.

II.—Some Examples of Folds and Faults in the Devonian Rocks at and near Ilfracombe, North Devon.

By Henry Hicks, M.D., F.R.S., Sec.G.S.

Introduction.

In a paper read by me before the Geological Society of London on November 26th, 1890,[1] I mentioned that I had obtained evidence during a recent visit to North Devon which had led me to believe that far too little importance had hitherto been assigned to the results of movements in the earth's crust as affecting the succession of the rocks in that area. I mentioned also that the supposed continuous upward succession from the rocks on the shore of the Bristol Channel to those in the neighbourhood of Barnstaple, including, according to some authors, no less than ten distinct groups, was an erroneous interpretation; for the beds are greatly plicated and faulted and several times repeated. Therefore instead of being one continuous series with a regular dip to the south, the beds are much folded in several broken troughs. In this paper I purpose giving some examples of the folds and faults near Ilfracombe which will enable those who visit that neighbourhood to verify the statements which I have made in regard to some of the rocks in that area.[2]

It will be seen that the beds have been constantly inverted and the folds broken, so that older beds have been made to appear to overlie conformably newer beds. The movements have taken place mainly in one direction, and the rocks near the fault-planes have been much sheared.

---

[1] See Abstract in Proceedings Geol. Soc. No. 562, and Geol. Mag. Dec. 1890.

[2] The Morte Slates, which have always been classed as newer than the Ilfracombe beds, I stated in the same paper to be the oldest rocks in the area, and they are now proved by their contained fossils to be of Silurian age.

COMBE MARTIN BAY.

In the beds along the East shore of Combe Martin Bay from Hangman Point to Combe Martin, there are many instructive examples of folds and faults. From Hangman Point to Wild Pear Beach there is a succession of thick beds of grits and flaggy sandstones which, at and near the point, dip generally to the south at an angle of about 35°. Nearer Wild Pear Beach they become bent into sharp folds, and at the north-east corner they are cut across by a fault as shown in Fig. 1. The beds north of the fault are mainly red, purple, and grey grits and sandstones with some intercalated flaggy beds, but immediately south of the fault flaggy and slaty calcareous beds are met with, here much crushed. In the point which separates Wild Pear Beach from Sandy Bay the flaggy sandstones which, in natural order, overlie the Hangman grits, and which separate the latter from the calcareous beds, reappear bent into acute folds which reach to the top of the cliff, as seen in Fig. 2. Between here and Combe Martin the beds are greatly folded and frequently broken, but the succession is easily traceable.

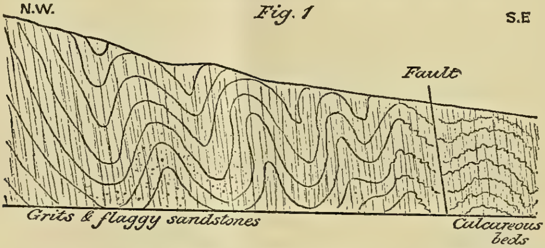


FIG. 1.—Cliff-face N.E. shore of Wild Pear Beach, Combe Martin Bay.

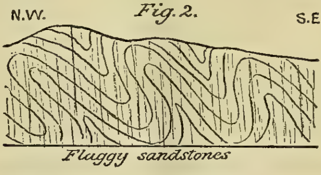


FIG. 2.—Cliff-face N.E. shore of Sandy Bay, Combe Martin.

The succession, as seen in the cliffs between Hangman Point and Combe Martin Harbour, indicates such an order of deposition as would accompany a gradual depression with a shore-line not far north of the Hangman Point. The lowest or massive grit and sandstone beds are clearly followed in true succession by the finer flaggy beds, and the latter by slaty and calcareous beds. Certain fossil zones which can be traced often offer evidence to prove that the beds are inverted when the folds are too much broken to be easily followed. Near the crest of the hill north of Combe Martin Church, red and purple grits belonging to the lower or Hangman beds are again to be seen under the flaggy beds, hence it is clear that another important fault separates these beds from those exposed in the low ground on the north side, viz., the West Challacombe calcareous beds. The succession as traceable in a section in a line south from Combe Martin shows that the flaggy and slaty beds which underlie the calcareous beds rise up higher and higher in the hills until they at last abut against highly cleaved slates of the Morte series type, thereby forming a main trough but containing several subsidiary folds with the calcareous beds occupying the highest stratigraphical position.

In following the coast-line from Combe Martin towards Watermouth, numerous folds in the flaggy and in the calcareous beds are recognizable, and the somewhat complex fold (Fig. 3) is seen in a limestone quarry on the roadside, about a mile west of Combe Martin. It will be noticed that the larger folds of the limestone bands, in themselves fairly acute, have developed, during the pressure, numerous minor folds, and that these have, in places, yielded so far to the pressure that the limbs of the folds have been almost brought together. The movements which have taken place have also nearly obliterated all traces of stratification in the associated argillaceous beds by inducing in them a highly cleaved state. Had this fold been subjected to still greater pressure, it would have assumed the condition frequently witnessed in some of the cliff sections, where, owing to the wearing away of the arch of the fold, band after band seem to lie in true succession, whilst in reality they are but the same band several times repeated in an inverted state.

Fig. 3.

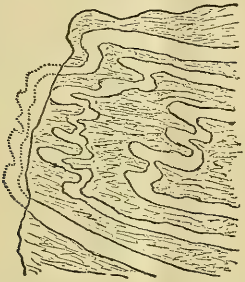


Fig. 3.—Folds in limestone Quarry, road-side, about a mile W. of Combe Martin.

At the Watermouth Caves, and on the shores of Watermouth Bay, several folds occur in the sandstone and flaggy beds. In the one at the Caves the arch has been broken in a line parallel with the strike, and this produced the line of weakness which subsequently caused the indentation or small harbour which occurs here. Fractures here are most frequent across the middle limb which joins the arch with the trough fold, but this is a good example of the effect of denuding forces acting on a broken arch of rather rough sediments affected by strong cleavage.

HELE BAY AND HILLSBOROUGH.

The beds on the east side of Hele Bay from Rillage Point to Hele Village are, as a rule, intensely folded. The limestone bands are repeated over and over again, and the underlying slates and flaggy sandstone beds are also traceable in broken folds below them. There are also numerous thrust faults which aid in producing the frequent repetitions of the beds. A superficial appearance, owing to the strong cleavage planes, leads one at first to suppose that there is a fairly well-marked succession with a general dip to the south, but a closer examination shows how entirely deceptive this is. The more one examines the beds on this coast, the more one is constantly reminded of the intensely complex arrangements which have been produced by earth-movements. The results in inducing cleavage and foldings on a small scale, in some of the sediments in this area, have been already referred to by Dr. Sorby, F.R.S.,[1] and by Mr. J. E. Marr, F.R.S.,[2] but I was entirely unprepared to find here evidences of such remarkably deceptive appearances in regard to the general succession which gradually made themselves apparent during my researches.

On the west side of Hele Bay the beds are bodily thrown forward by a fault which crosses the beds more or less in the line of the Valley. The section on this side passing through Hillsborough is most instructive as illustrating mountain-making by a series of parallel folds aided by thrust faults, especially as the beds can be examined in cliff sections in Hele Bay on the one side, and also in the precipitous cliffs and coves on the Ilfracombe side. Extending across the hill from the point between Rapparee Cove and Larkstone Beach are fairly gentle folds of sandstone beds, but between here and Beacon Point the folds become steeper and steeper, and at last are so much crushed and broken that the limestone bands in the higher beds near the Point are so cleaved as to look, at a little distance, like slates.

If the section is carried in a line south from Hillsborough it will be found that similar beds to those which form that hill are repeated in wider folds here and there broken across, but which on the whole form themselves into a fairly wide trough in which the sandstone beds mark the boundary on the south at a fault which separates the Ilfracombe beds from the Morte series.

ILFRACOMBE.

Lantern Hill and Capstone Hill, Figs. 4, 5, and 6, offer illustrations of fairly gentle folds broken on the north or seaward side; the result being a precipitous face on the over fold or broken side and an easy slope on the side of the arch limb. These show the conditions to be witnessed in the majority of the Torrs which are so plentiful in the neighbourhood, especially those formed of the massive sandstone beds, which of necessity are of a somewhat unyielding character. These folds also are frequently fractured in lines radiating outwards more or less from the core of the fold, which are quite independent of the cleavage planes. The lateral pressure which has been sufficient to produce these effects on the harder and unyielding beds, has, as has already been stated in the case of the beds at Hele Bay, affected the softer and more yielding calcareous beds in a far more marked manner. There are many excellent examples of folds in the harder beds on the shore at Ilfracombe which may be easily examined, and which

---

[1] Q.J.G.S. vol. xxxv. pt. 2, p. 89.

[2] GEOL. MAG. 1888, Decade III. Vol. V. p. 218.

Fig. 4.

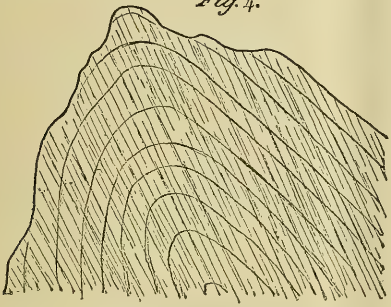


Fig. 4.—Fold in flaggy beds on the shore between Capstone Hill and Lantern Hill, Ilfracombe.

Fig. 5.

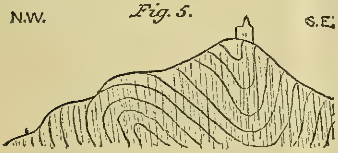


Fig. 5.—Section through Lantern Hill, Ilfracombe.

Fig. 6.

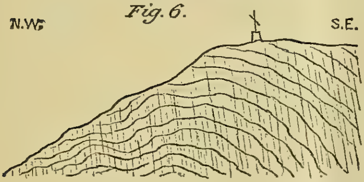


Fig. 6.—Section S.W. face of Capstone Point.

Fig. 7.

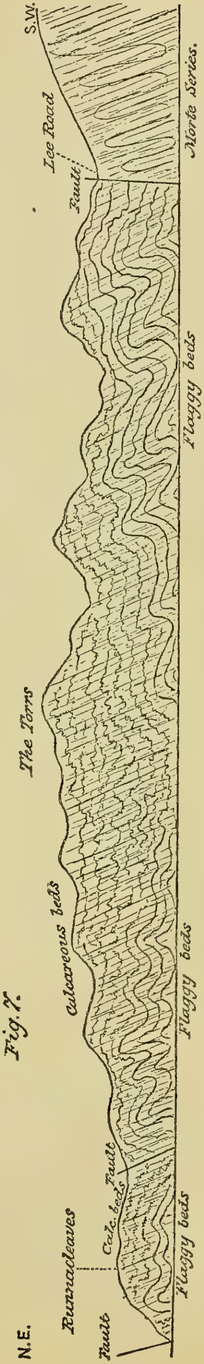


Fig. 7.—Section through the Torrs, Ilfracombe, from Runnacleaves to Lee Road above Flat Point.

exhibit in a marked manner the influence of intense pressure on sandstone and argillaceous material. There are those already referred to on each side of the Rapparee Cove, in the Lantern Hill and in the Capstone Hill, as well as the fold (Fig. 4) between the Capstone and Lantern Hills, and another interesting example on the shore under the Ilfracombe Hotel, all of which can be reached with ease. The glossy appearance of these rocks readily strikes the eye, and on examination it will be found to be due to the combined effects of shearing and of subsequent infiltrations along the crush lines. At Wildersmouth between the Capstone Hill and the Ilfracombe Hotel a fault crosses the beds, which, although not of much importance in regard to the question of succession, is yet interesting as showing the influences produced by cross faults on the physical features of a district, for most of the harbours and valleys in this area have had their direction determined by these faults as being the lines which offered the least resistance to denuding agencies.

Fig. 7 is intended to illustrate the general succession as traceable in the cliffs under the Torrs from near the Ilfracombe Hotel to the ridge beyond the last of the Torrs. At the north end of the section there is the sharp fold in the sandstone beds broken on the north side and much seamed with quartz veins in the line of the thrust fault. This is best seen, as already stated, under the Hotel grounds, but it is equally well shown at the Point outside the ladies' bathing place, where inverted and jagged-looking beds on the north side of the fold form a well-marked ridge. The beds at this horizon are freely covered with worm-tracks, and these offer an easy means of finding out whether the beds are inverted or not when the arch has disappeared. Overlying these beds at the bathing-place are the grit, argillaceous and calcareous bands which were described by Dr. Sorby as illustrating the development of slaty cleavage, and more recently by Mr. Marr,[1] to show some effects of pressure on sedimentary rocks. These beds being composed of softer and more yielding materials than the underlying beds, have given way much more readily to the pressure, and the result has been to induce a strong cleavage in the argillaceous beds which has, as seen in Fig. 8, nearly obliterated all evidence of stratification, and which has broken the limestone and also some quartz bands into lenticular fragments having their long axes parallel with the cleavage planes.

Fig. 8.

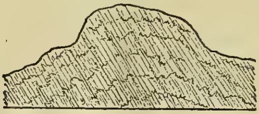


Fig. 8.—Cleavage nearly obliterating bedding in slaty beds, quarry, Torr's Park Road.

Beyond this point the calcareous beds rise higher and higher in the cliff, and at last form the central group of Torrs. The Torrs further south are, in the main, composed of sandstones and flaggy beds, but with some of the slaty and calcareous beds also folded in. The sandstone beds may be easily examined on the Lee (Cliff) Road at the junction of the Upper Torr's Walk with the Lee Road, and also on the coast below the last two Torrs. In the cliff, north of Flat Point, the beds are much crushed, and show clearly that there is an important fault separating the beds which compose the Torrs from the highly cleaved slates of the Morte series, which form the high ridge on the south side which intervenes between here and Lee.

---

[1] Geol. Mag. 1888, Decade III. Vol. V. p. 218.

It will be seen that the interpretation here given of the succession along the Torrs, and elsewhere in the Ilfracombe district, differs in a very marked manner from that generally adopted. Instead of interpreting the Torrs as formed of outcrops in a succession of hard and soft beds having a regular dip to the south, they are here shown to be due to foldings and fractures of the strata, the wider Torrs with even slopes on the south side being formed mainly of hard and unyielding beds, and the smaller and less regular ones of softer argillaceous and calcareous rocks. The realization of these facts will necessitate, in future, a great reduction in the thickness hitherto given to the Ilfracombe series, and the re-arrangement of the fossil zones. These points will be dealt with further in a forthcoming paper, which will include also the description of the Morte series and its fauna. The Morte slates have been described as entirely barren of organic remains. My researches have now proved that they are everywhere fossiliferous, and that they contain a fairly rich fauna.

III.—Eskdale Drift and its Bearing on Glacial Geology.

By T. Mellard Reade, C.E., F.G.S., etc.

Part I.

THE extraordinary abundance and almost universal distribution of fragments of Eskdale granite through the Drift of the North-West of England and part of North Wales is an impressive fact to the student of Glacial Geology. Mackintosh was the first to systematically trace this rock through the Drift and to note its origin. Since the time of this single-minded and patient investigator many other geologists have gone over the same ground and extended his observations, and all must bear witness to the accuracy of his facts.

In this paper I propose to speak only of the facts of Glacial Geology which I have personally observed, so that absence of reference to the work of others must not be construed into insensibility to their merits. Indeed, were I only to name all the meritorious workers even in this area of Great Britain the space at my disposal would prove all too short.

Distribution of the Eskdale Granite.

In almost every section of Drift from St. Bees, in Cumberland, to the south of Shropshire, and from Macclesfield across to Wales, and thence along the coast as far as Nevin, in Carnarvonshire, a more or less careful search will yield to the experienced observer some fragments of this rock either as minute pebbles or good sized boulders. It is usually readily distinguished from the Scotch granites by the characteristic prevalence of a light pink felspar and often by a much coarser grain. There is, however, a second variety of granite having its birth in Eskdale which is of a blue-grey colour but still recognizably different to the grey granites of Dalbeattie and Cairnsmore of Fleet.

Pebbles and boulders of Eskdale granite, usually considerably water worn, and bearing none of the characteristic marks of glaciation, are found in the Drift at all levels from 1400 feet above O. D. at Moel Tryfaen to below the sea level in estuaries where engineering works have made us acquainted with the subaqueous glacial drift. Therefore it is remarkable not only for its horizontal, but also for vertical range.

The Parent Rock.

The area and distribution of the Parent rock is shown upon Sheets 98 N.W. and 99 N.E. of the Geological Survey, and are given in outline on Fig. 1, p. 17. It commences at Muncaster Castle in Eskdale, and extends up the vale as far as Eskdale Fell. Miterdale, parallel to and to the North of Eskdale, is also excavated in this granite, and it extends over to the foot of Wast Water.

Roughly it may be considered a tract 8 miles long in a south-westerly direction by an average width of 4 miles, and an area of about 32 miles. Its highest part is just south of Wast Water, about 1400 feet above O. D., and it is found at nearly sea-level in the lower parts of Eskdale and Miterdale. In all this area there is only one Granite quarry, and, curiously enough, it is in the bluish-grey variety, which, though an excellent granite, is not at all the distinguishing rock of the Vale. It is at Broad Oak, Waberthwaite, and is worked for monuments, kerbs, setts, etc.

Glacial Drift of Eskdale.

Basal Granitic Drift.—The basal drift lying upon the Granite in Eskdale is composed of angular and subangular fragments and blocks of granite mixed with a smaller number of boulders from the Volcanic series through which the granite was extruded and which surrounds it on all except the seaward side. An angular unstratified granitic sand fills up the interspaces between the stones, the whole having a decidedly reddish hue. I have searched for marks of glaciation on the granite blocks and fragments but very rarely found any. In those few cases where glacial markings were perceptible they took the form of rubbed slightly channelled surfaces without striæ. On the fine-grained volcanics which, as a rule, are more worn and rounded than the granite, fine striations were often seen, but not so often as in the Low-level Marine Drift of the Lancashire plains. Up Eskdale and Miterdale as the Volcanic series are approached boulders of these rocks begin to preponderate.

High-Level Glacial Gravels.

At a level of about 1600 feet above O. D. on the edge of the Screes overlooking Wast Water (see Fig. 1, p. 17) is a deposit of subangular gravel so far as I could make out entirely composed of the rocks of the volcanic series. It is about 8 feet thick where I first saw it, and can be traced along the summit of the Screes up to nearly 2000 feet above O. D. Unlike the Drift of the valleys already described, these gravels show marks of glaciation in the shape of flattened surfaces, striæ, and scorings, at all angles.

I brought quite a number of specimens away with me. Many of them have been very much weathered, as might be expected from their exposed situation, but still, even where the stone is much eaten into by surface decomposition, the characteristic glacial shape is often preserved. These gravels show on the north-west edge of the Screes, evidently through the falling of the cliff-rock on which they repose, exposing from time to time fresh surfaces. The rain washing away the smaller material in which they are imbedded, leaves the upper surface of gravel clean and conspicuous. The largest striated stone I observed was 7 inches across, and flat on opposed sides. There is no doubt that the flat surfaces are largely due to jointing, and it is on these plane surfaces that the stones have been pushed along, polished and striated. The smallest gravel is often striated all over, and it is quite evident that the original shape of the stone influences considerably its mode of glaciation.

At Miterdale Head there is a ravine or wash-out in the Drift with which this part of the mountain is deeply covered. Its level, where I examined it, is from 1400 to 1500 feet above O. D. The Drift is here of a very similar character to that on the summit of the Screes, but hardly so much glaciated. On digging into the deposit, a little below the surface-wash, it appeared to be a grey Till.

I think that the Drift on the Screes is probably similar in nature. I took samples of the loamy matter in the Screes Drift, as also in that at the head of Miterdale. A mechanical analysis by means of sieves yielded the following results.

TILL FROM THE SCREES, WAST WATER, 1600 FEET ABOVE O. D.

Weight before washing 6 ounces.

Percentages.		Ounces.
·465	caught in $\frac{1}{20}$ inch mesh	2·792
·069	,, $\frac{1}{40}$,,	0·416
·100	,, $\frac{1}{100}$,,	0·604
·208	passed $\frac{1}{100}$,, (fine sand)	1·250
·158	(clay)	0·938
1·000		6·000

TILL FROM RAVINE NEAR MITERDALE HEAD, 1485 FEET ABOVE O. D.

Weight before washing 6 ounces.

Percentages.		Ounces.
·562	caught in $\frac{1}{20}$ inch mesh	3·375
·055	,, $\frac{1}{40}$,,	0·333
·111	,, $\frac{1}{100}$,,	0·666
·173	passed $\frac{1}{100}$,, (fine sand)	1·042
·099	(clay)	0·584
1·000		6·000

The material is all more or less angular, and is mainly, even to the smallest grains, from the volcanic series. There are some quartz grains, but none that I could see were rounded or polished.

Marine Boulder and other Drift.

This Drift may be observed in many gravel pits in Eskdale and Miterdale and between Eskdale Green and Santon Bridge. A specially good example of it may be seen in a large gravel pit between Ravenglass and Muncaster Bridge about 270 feet above O. D. (No. 1 on Map, Fig. 1, p. 17).

This Drift is composed to the largest extent of angular, subangular, and very rounded boulders of Eskdale granite. I noticed one very large boulder of grey granite. There were a good many very rounded pebbles of St. Bees sandstone, and I noticed one flat angular piece measuring eight inches across. Two small flints were found here also. Glaciated volcanic boulders and pebbles are next in frequency to the granite. A microscopical examination of the sand which accompanies this Drift shows that it is partly composed of rounded and worn grains of quartz mixed with a larger proportion of angular and subangular grains and broken crystals of quartz evidently derived from the disintegration of the granite. It is on the whole a decidedly large grained sand.

A smaller gravel pit at How Bank between Muncaster Bridge and Eskdale Green, on the left bank of the Esk (No. 2), shows a section of similar gravels and boulders in this case current-bedded. At Harrison's Farm (No. 3) in Miterdale, at about 250 feet above O. D., there are laminated sands horizontally bedded, overlaid with current-bedded gravels of the same series disclosed in a sand and gravel pit.

Between Eskdale Green and Santon Bridge several pits in this series can be seen, noticeably one at 335 feet above O. D. (No. 4), in which is a bed of fine laminated gravel, intercalated in a turbulently bedded stony Drift. The stones are mostly granite, well rounded and showing a brilliant colouring. There are volcanics intermixed, one of which was striated.

On the right hand side of the road in descending towards Santon Bridge an interesting section occurs in a considerable gravel pit having a level of about 320 feet above O. D. (No. 5). The base is composed of a hard reddish buff Till, upon which is sand and fine gravel current-bedded and irregular. Above this is a coarser gravel and there are a good many large blocks mostly Volcanics; one I measured being 5 feet × 4 feet × 4 feet and well striated. Some are of ash and very irregular in shape. Towards the top a few small pieces of St. Bees sandstone occurred, together with another sandstone I took to be Carboniferous. Granites similar to Eskdale are mixed up with the boulders, and are mostly rounded.

There is a considerable development of the Drift on the Wasdale side of the divide.

Drift of the Plain from Santon Bridge to Calder Bridge.

From Santon Bridge to Calder Bridge the country is covered with Drift Sand and gravel, which extends westwards to the coast and is connected with the Drift of St. Bees. Sections of this sand can be seen on the Rivers Irt and Calder which have deeply excavated into it. It mostly lies upon the Permian Sandstone but overlaps the Volcanics inland near Gosforth where good sections may be observed on the River Bleng. It is undoubtedly marine. The base on which this drift rests may be seen in a quarry of Permian Sandstone above the Bridge over the Bleng at Sourmire (No. 6) about 400 feet above O. D. It consists of hard foliated red sand containing a little clay with angular and subangular pieces of the red sandstone embedded in it, together with pebbles of the Volcanic series.

On the left bank of the Bleng nearly opposite the quarry just described, there is a good section of drift about 25 feet high (No. 7). Here, curiously enough, it is a buff clayey hard till, full of Volcanics, but Sandstones seem to be absent. It lies on the Volcanic series of rocks and there is a large bank of it here. Between Hall Boltom and the bridge carrying the Gosforth road over the Bleng, is a deposit of sand like that on the Irt.

Calder Abbey stands upon a terrace cut out of the Drift which, though looking so recent, is evidently a very old feature estimated by years. It cannot have changed appreciably since the building of the Abbey in 1180, the escarpment bounding the platform on which it stands being quite sharp and unmodified.

Beyond Calder Bridge in the direction of Whitehaven the old river scarp comes up to the road (No. 8). This bank is made up of loamy red sand full of large boulders and pebbles of St. Bees Sandstone exceedingly well rounded, together with rounded Volcanic pebbles. Some of these Sandstone-boulders are a little indented and scratched. I observed here a good sized boulder of Buttermere Granophyre. This Drift is all marine.

Coast Sections.

From Braystones to St. Bees are very good sections of this sand and gravel Drift which I have described in part in my paper "On the Drift Beds of the North West of England and North Wales."[1] South of Nethertown Station there is a good section of sands and gravels. At the south end of the section are blocks of St. Bees sandstone up to five feet across, embedded in the Drift. Near here my son Aleyn found an indented boulder of fine soft Yellow sandstone, probably Carboniferous, also partly covered over with a deposit of carbonate of lime cementing the gravel thereto. Coal flakes in laminæ occur in the sands, and also shell gravels. The sand grains are large and well rounded. At the north end is the Faulted Drift described in the Geological Magazine for November, p. 490.

Among the Drift stones are a good many rounded pebbles and some boulders of Eskdale granite, and these are found all along as far as St. Bees. The sections of Drift at St. Bees before referred to as described by me in 1883 (but seen in 1872) are not now so clear, being covered by a good deal of talus-wash, but sufficient is seen to show that the beds now exposed differ considerably from those observed in 1872, though the principal characteristics remain the same.

---

[1] Q.J.G.J. vol. xxxix. (1883), pp. 108–111.

Marine Drift in the Valley Bottoms.

In the flat bottom land between and connecting the valleys of Miterdale and Eskdale, between Irton Road and Eskdale Green stations on the narrow gauge railway, is a deposit of sand, gravel, and boulders (No. 9).

The boulders and gravel lie upon fine laminated sand, and are of well rounded Eskdale granite, both pink and grey, together with a good many Volcanics. Intermixed with them was a large percentage of extremely well rounded pebbles of St. Bees sandstone up to four inches diameter. The level is about 145 feet above O. D., and they must have travelled up either Miterdale or Eskdale, probably Eskdale. As this drift lies on the granite and the Permian sandstone is at the nearest point in Miterdale between two and three miles to the westwards, and in Eskdale four miles, it must have travelled at least the minimum distance stated up one of the valleys, but probably much more.

At the private bridge over the Esk, near Muncaster Head (No 10), there is a section of this sand-drift, here all sand, full of extremely rounded and very small pebbles of St. Bees sandstone. The sand possesses all the characteristics of Marine sand, consisting principally of very rounded quartz grains, intermixed with angular unworn grains, evidently the débris of the granite. I believe that the worn grains are also of the same derivation, as they are much larger than those of the Permian sandstone. It is the result of wave and current action. There is evidently a bank of this sand lying against the foot of Muncaster Fell, which has been scarped by the river Esk. The general form can be well seen from Eskdale Green. Rabbit burrows show that this sand, with Permian sandstone pebbles, extends to at least 140 feet above O. D. Similar sand may be seen on the opposite side of the valley on the road to Muncaster (No. 11).

Perched Blocks and Moraines.

Scattered over the mountains, angular perched blocks of granite may be seen, evidently the last records of the Glacial period in this district. In ascending the footpath from Miterdale to Wasdale at a level of 700 feet above O. D., I noticed a perched block of granite balanced in a remarkable manner on its thinnest edge on granite *in situ.* It measured 18 feet high by 10 feet and 15 feet, on the sides. It was evidently kept in position by slightly leaning on the lower part against the rubbish of the mountain side.

Above Boot, by the bridge over the Esk, on the way to Hardknott, moraines of gravel and boulders may be seen. They are well developed for a considerable distance up the valley above the bridge, and have been scarped in several places by the river, which has evidently effected considerable denudation since the glaciers died out. Upon these moraines are to be seen, here and there, large blocks from the Volcanic series. One of two, by the bridge, measured 8 feet by 6 feet by 5 feet, and lay at a level of about 275 feet above

O. D., the moraine rising 20 feet above this. On the opposite side (left bank) there is a well developed terminal moraine truncated by the river, and upon it at a level of 345 feet above O. D. lay another Volcanic block 10 feet by 8 feet by 5 feet.

A large quantity of morainic matter lies at the foot of Wast Water, and may be well seen while descending the footpath from Miterdale. I believe it to be a terminal moraine, but it has no doubt been laid down in water, as a section in a gravel-pit at the junction of the road to Strand shows a laminated book-leaf clay of a hematite-red colour, intercalated between a hard clayey buff Till and a current-bedded stony Till. The basin of Wast Water seems peculiarly free from Drift.

Part II.

Early Glacial Conditions.

The Glacial history of this district commences with an accumulation of snow, which increased until it covered the whole of the mountains and valleys of Cumberland, giving birth to glaciers of considerable dimensions. My observations in other places have led me to believe that the land at this time stood at a much higher level relatively to the sea than at present, and that the Irish Sea was non-existant. Although the evidences of this are not, in my opinion, as complete as are the records of later phases of the Glacial period, they are important. A system of Pre-Glacial valleys[1] exists, and can, in fact, be traced in the Mersey and the Dee, and other rivers of the north-west of England, which could not have been excavated under present conditions of level. Again, there are no signs in any of the excavations made in connexion with sea works, docks, and rivers of the existence of beds holding a fauna older than that of the Glacial period. It is not, however, of this period I propose to treat, as I do not consider my observations in Eskdale throw any new light upon it.

Dispersion of Eskdale Granite.

To any one like myself who has seen boulders and pebbles of Eskdale granite in the Drift dispersed over hundreds of square miles of country far away from its origin and associated with evidences of intense glacial action, it is very striking to notice in the birthplace of the boulders so few signs of glacial action on the rock itself. It is true that rounded contours are to be observed on many of the granite bosses, but as a rule the surface of the granite is singularly jagged even under the Drift. The rock appears to have been torn up and dislodged in consequence of the system of jointing, in cubical masses, which have not been pushed along in the till upon certain planes but have rolled over and constantly changed their positions. The rock is also incapable of receiving fine striæ and indents.[2]

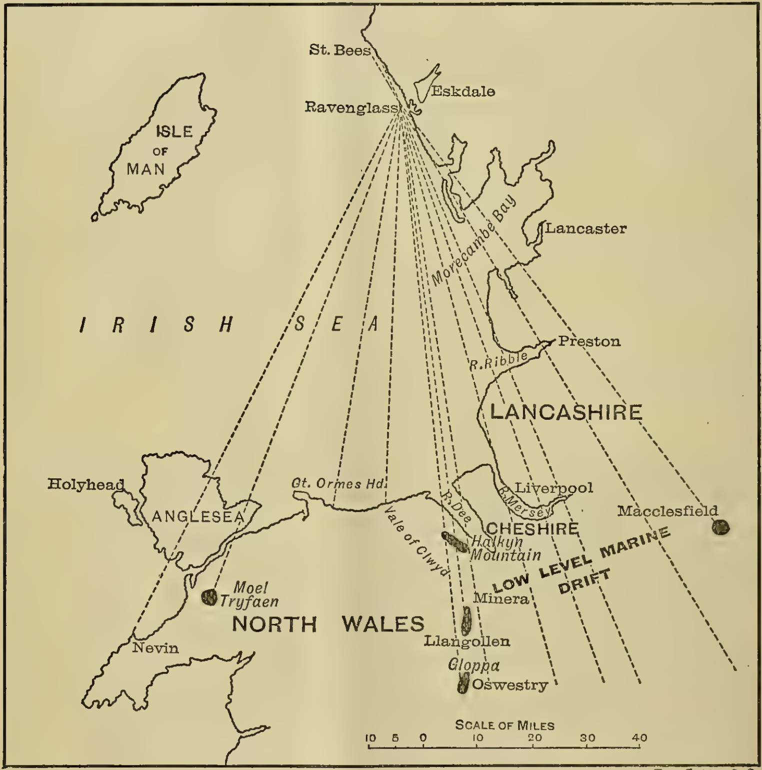
---

[1] Buried Valley of the Mersey. Proc. Liverpool Geol. Soc. 1872–73, pp. 42–65.

[2] Griesbach says that he entirely failed to discover glacial scratches in the moraines at the end of the Himalayan Glaciers. (Mem. Geol. Survey of India, vol. xxiii.)

It is very instructive to contrast the effect of glaciation on the fine-grained rocks of the Volcanic series, which are found among the granite boulders with the granite. These stones are often flat, also due to a prevalent system of joints, and these plane surfaces have been polished smooth and covered with fine striæ.

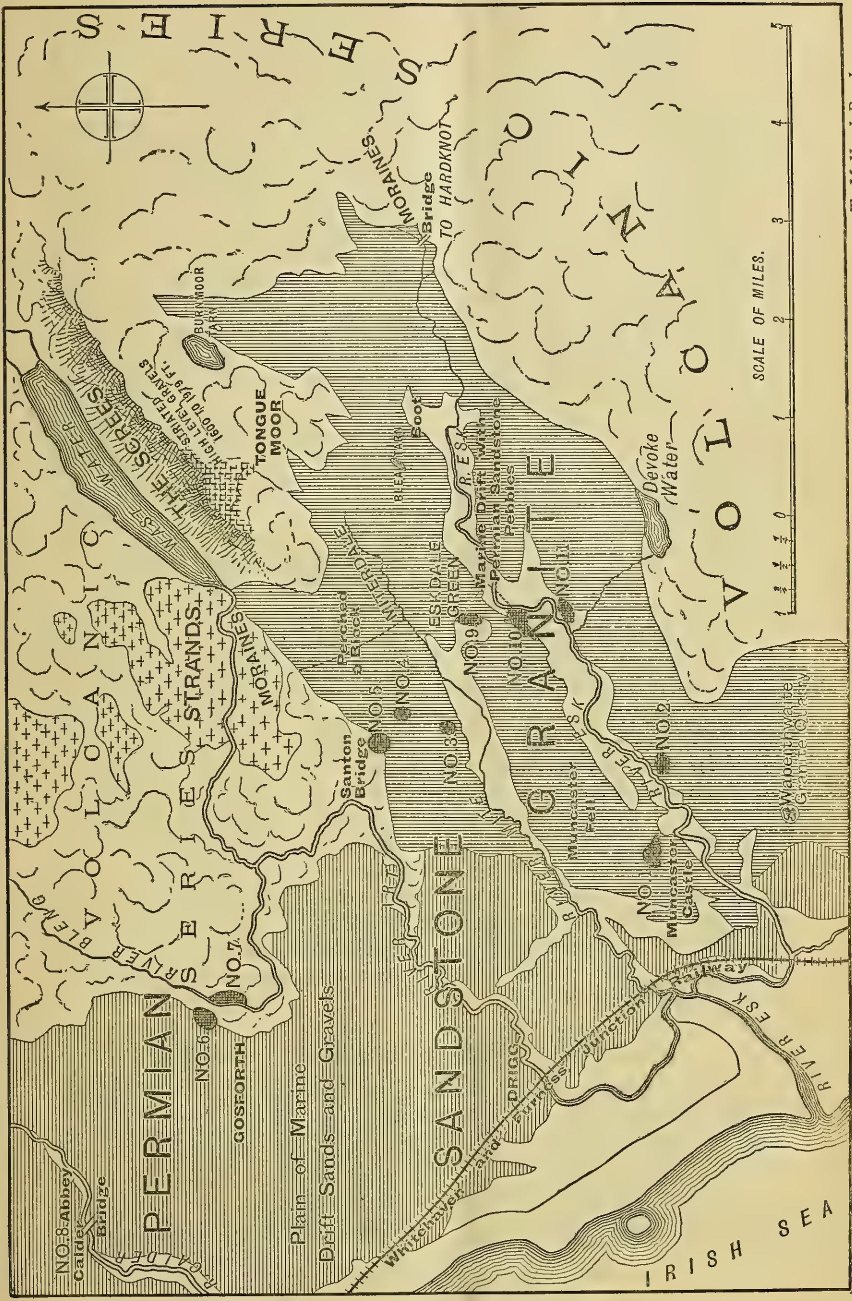
The shape of the stone as well as its nature evidently influences the mode of glaciation. Some irregularly shaped stones are covered with the most extraordinarily confused intersecting scratches. That the granite boulders have been brought down the valleys by glacial ice notwithstanding the facts stated admits of no doubt; but in what way they have been dispersed south, west, east, and even north in view of the ideas put forth by the new school of glacialists is a question worth examining. In the accompanying Map, Fig. 2, the distribution of these erratics is roughly shown, the dotted lines exhibiting the direct course from the point of origin, not the actual course travelled, which cannot be known.



Typo-Etching Co. Sc.

T. Mellard Reade, del.

Fig. II.—Map showing dispersion of Eskdale Granite.



T. Mellard Reade.

FIG. I.—MAP SHOWING RELATIONS OF ESKDALE DRIFT TO THE COUNTRY ROCKS.

Has the Carriage been by Land-ice?

It will be seen that the lines of travel between Carnarvonshire and Macclesfield diverge at an angle of 66 degrees, and between Macclesfield and St. Bees they sweep through as much as 180 degrees. The question arises if these fragments of the parent rock have travelled to their several localities by means of land-ice, as asserted very positively by the new school of glacialists, what sort of internal flow and movement of the ice does this involve? According to the well-known axiom of geology we must explain geological phenomena by reference to natural agencies now to be observed in action. If this cannot be done by exact parallel we must appeal to some well known principles of physics to help us out. We must show that the conditions differ and in what way and to what extent.

The only knowledge we possess of the nature of the movement of land-ice is that in the form of glaciers in mountain districts. A glacier, such as it is assumed filled the Irish Sea, unless we can point out good grounds to the contrary, must be considered to march along on the same general principles as those glaciers we are acquainted with having steeper gradients. Any one who has seen a glacier, or the photograph of a glacier, will have observed that the material dropped upon its surface from abutting cliffs and also that which joins it from tributaries retains as definite and distinct an existence as a tramline in a main highway. This fact may be observed in every Alpine glacier, and it needs only a glance at the admirable photographs of the glaciers of the Central Himalayas given by Griesbach[1] to tell us that the same holds good in Asia. If, therefore, we are to consider that an ice-sheet made up of confluent glaciers acts differently and disperses throughout its mass, the stones taken up at one point distributing them generally and regularly over an immense area instead of in trains, the onus of proof lies on those who believe such to be possible. Personally I consider it to be a mechanical impossibility. Glacial ice moves along lines of least resistance, and these lines within certain limits, and under common conditions, are approximately parallel. A glacier from Eskdale, joining a main stream of ice from Scotland along the Irish Sea, would have its burden taken in train and deposited on a definite line, not distributed through the moving river of ice. We should find the probable record of its line of travel in the Drift itself.

Phenomena of distribution points to Water Carriage.

But why should we go out of our way to displace the Irish Sea with land-ice to provide transport for our dispersed blocks? The evidence that the bulk of the Drift of the plains, and much of the high-level Drift, is sea-bottom, whether in place or displaced, is so strong that no one attempts to gainsay it. Water carriage provides the very thing that is wanted to explain the dispersal of Eskdale granite boulders. Unlike the movement of ice, the sea is subject to flux and reflux twice a day to consequent change of current for every hour of the day. Its surface, and anything floating thereon, is affected by winds, changeable, but having a more or less prevalence of direction.

---

[1] Mem. Geol. Survey of India, vol. xxiii.

All the conditions necessary to satisfy the problem of boulder distribution are here, if we add floating ice; but the explanation so close at hand, and so complete, is thrown aside, ostensibly because it involves submergence of the land to a greater or less extent.

What Marine Drift in Eskdale tells us.

As I have shown in the preceding pages, Marine Drift is found in Eskdale and Miterdale up to a level of 400 feet above the sea. This Drift is similar to, and the equivalent of, the Marine Drifts found up to the same level on the coast of North Wales. The supporters of the Irish Sea glacier hypothesis contend that these sands, gravels, and clays, together with similar Drift at higher levels on Moel Tryfaen, Halkin Mountain, between Minera and Llangollen, and on Gloppa, have been pushed up in opposition to the local Snowdonian and North Wales glaciers by the hypothetical Irish Sea glacier after traversing the sea bottom. This explanation will not, however, account for the presence of Marine Drift in Eskdale and Miterdale.

The Permian sandstone-pebbles found up to a level of 320 feet above O. D. could not have been pushed up by land-ice from the Irish Sea against the general flow of the valley-ice. The ice-sheet bearing down from Scotland would have had to turn sharp round at right angles and flow up Eskdale to have effected this. If such an extraordinary thing did happen, in what way, we may ask, have Lake District rocks got conveyed to the Isle of Man,[1] or how have Eskdale granite boulders and pebbles been carried north-westerly in direct opposition to the hypothetical ice-flow, as far as St. Bees? Test it in any way we may the ice-sheet explanation breaks down here.

Extent of the Submergence.

Although in this district I observed no evidence of submergence higher than 400 feet above mean sea level, it must not be inferred that that was its maximum limit.[2] It would take a very careful survey of a much larger area of the Lake District to offer an opinion worth having as to the extent of the maximum submergence. The glaciated gravels at the top of Screes, Wast Water, and down to a level of 1300 feet above the sea are of an altogether different type to the marine gravels of Eskdale, and appear to be a purely glacial product, and considering that they extend to the very edge of this great scarp, a very interesting one too.

---

[1] "There is abundant evidence too of a strange intermingling of foreign rocks in the till, *which must have travelled from the coast of Cumberland* (the italics are mine), the South of Scotland and the North of Ireland" (Sketch of the Geology of the Isle of Man—Horne—Trans. of Edinburgh Geol. Soc. vol. ii. part iii. 1874).

[2] The late Mr. Clifton Ward (Geology of the Northern Part of the English Lake District, Mem. Geol. Survey) considered there were evidences of very great submergence, but as I have not visited the localities he names, and am not clear as to the grounds on which he judged the Drifts he mentions to be Marine, I cannot use his observations.

Conclusion.

There are many more interesting problems connected with the extent and distribution of Eskdale Drift, such as the vertical amount of denudation which the granite area suffered during the Glacial period, the length of this period, and the extent of time which has elapsed since its close. To all these questions the Glacial geology of Eskdale and Wastdale might, I think, be made to yield some more or less certain answers. I will not, however, peril the simple object of this paper by discussing such recondite problems. The object of my investigation was to test the bearings of the Glacial phenomena of Eskdale upon the current theories of glaciation, and this done I must for the present conclude.

IV.—THE TRUE HORIZON OF THE MAMMOTH.

THE FOREIGN EVIDENCE AND GENERAL CONCLUSION.

By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.G.S., etc.

IN previous communications to the GEOLOGICAL MAGAZINE I have subjected the evidence as to the age of the Mammoth in the British Islands to criticism, and I ventured to conclude that wherever we can find the remains of the Mammoth and its contemporaries undisturbed and *in situ*, these remains are found under and not over or in the drift. This, so far as I know, is the case in every recorded instance where the Mammoth beds and the drift have been found superimposed upon each other.[1] Let us now turn to the Continent and test the problem there. If we are to test it in the same way, which I take to be the only satisfactory way, namely, by evidence of superposition, we must naturally limit our survey to countries where the drift actually occurs. First, let us turn to Switzerland.

Whenever the sequence has been actually ascertained, that is to say, ascertained by one set of deposits being superimposed on the other, it seems to me that the beds with quaternary mammals, in Switzerland, always underlie the erratic beds. Thus, a skull of the Mammoth was found, in 1841, four kilometres from Rapperschwyl, in the Canton of St. Gallen. According to the section published by Escher von der Linth and C. Martins, the beds in this case lay in the following order:

1. Black and angular fragments of glacial origin.
2. Rounded pebbles and boulders, sometimes as big as a man's head, like those in the Nagelfluh.
3. Bluish and yellowish clays.
4. Bituminous remains of wood mixed with sand and clay.
5. The Mammoth's skull in question.

---

[1] I overlooked the very important and notable case at Selsea, where the Mammalian bed is overlain by a deposit with boulders and greywethers.

6. Greyish clay and fine sand, containing *Planorbis*, *Paludina*, and *Cyclas*.
7. Molasse and Nagelfluh of Tertiary age.[1]

This is a very good example, and it seems to be very conclusive.

According to the same authors, bones of the Mammoth have been found by M. Miollet, in the valleys of the Jura at Neuchatel, in a thin stratum of diluvium gravel, composed of Jurassic and Tertiary pebbles, and covered by glacial débris, consisting entirely of Alpine rocks.[2]

Let us now turn to the famous lignites at Dürnten and at Utznach, near Zurich, upon which so much has been written. It has been often said, on the authority of Professor Heer, that the beds in question are intercalated between beds of drift. Heer, however, writes most guardedly on this subject. "In Eastern Switzerland," he says, "until recently the upper erratic formation only was known which overlies the stratified pebble beds. At Utznach, in a section on the road to Gausen, now again covered up, Prof. A. Escher von der Linth saw quite distinctly the direct superposition of the lignite formation upon the Miocene beds; so that at least, at this point, there were no traces of erratic blocks to be seen between the Miocene beds and the lignites. At Dürnten also, the clays under the lignite formation only contained such stones as may have been derived from the conglomerates of the surrounding hills. The hypothesis of two Glacial periods does not, therefore, seem to be supported by the facts observed in Eastern Switzerland." The same views are maintained by Sir Charles Lyell. He visited the beds at Utznach in company with M. Escher von der Linth, and those at Dürnten with Professor Heer and M. Marcou. "The beds in both places," he says, "are of the same age. At Utznach the lignite beds rest directly, but unconformably, on highly inclined, and sometimes vertical, Miocene molasse, and are covered with gravels, and these again with erratic blocks," and he distinctly says that the evidence is wanting at Utznach to establish their interglacial character.

In regard to the deposits at Dürnten, M. Charles Grad, who examined them with great care, found the underlying beds to consist of light-coloured clays or marls, such as occur in freshwater beds in lakes and marshes. These marls contain numerous rolled pebbles, but M. Grad says, "je n'y ai pas remarqué de stries glaciaires."

It would seem, therefore, that so far as the beds at Dürnten and Utznach are concerned, the evidence is against their being underlaid by any drift deposits, and confirms the British evidence. We are told, however, that a different conclusion must be drawn from a similar bed occurring at Wetzikon, near Dürnten (in which the plants were exactly similar to those at Dürnten, and which is doubtless of the same age), and that there Alpine blocks had been found underneath the lignite. The evidence about it, however, is very unsatisfactory. In the first place, Heer speaks of this lignite bed as of small extent. In the next place, it is unfortunate that this particular and most important section should have been entirely covered up, and be no longer available for study. It is also unfortunate that it should have been an artificial and not a natural section. Mortillet has pointed out that such sections made by workmen, and not under the eye of scientific men, are very unsatisfactory. Speaking of this very section, he tells us how easy it is in deep pits through soft strata, to have a slipping of positions of the beds. M. Charles Grad, again, in discussing it, says that it was much disturbed. He had himself noticed a streak of gravel traversing the lignite; in another place the same lignite was penetrated by a wedge of clay. In some places it rested in small pockets on the gravel and the clay, in others it was standing vertically, and merely covered by vegetable soil. "These circumstances point," he says, "to slipping or crushing of the lignite beds after they were formed." This description, by one who examined it, and the conclusion forced upon him, surely destroy the whole value of the section as a crucial and critical test, and, as Mortillet suggests, it points to the supposed subjacent Glacial beds, having been accidentally, and not naturally, so placed.

---

[1] See Bull. Soc. Geol. de France, 2nd ser. vol. vii. 1858, p. 601.

[2] *Id.* 602.

The stratigraphical evidence of the lignites we have described is completely at one with that of the animal remains found in them. These do not consist of the Mammoth and the Woolly Rhinoceros, but of the *E. antiquus* and *R. leptorhinus,* the same beasts found in the Forest Bed, which is at an earlier horizon than that where the Mammoth occurs, and *à fortiori* one more unlikely to occur among true glacial beds, and which is in front overlain by them. Neumayr, in his "Erdgeschichte," says that similar remains occur in the beds at St. Jacob, on the Biros, near Basle; in the Algau, near Somthofen; at Chambery and Sonnaz, in Savoy; and at Leffe and Val Gandino, in Upper Italy; in none of which places is the bed in which they occur intercalated between glacial beds.

M. Favre, in his paper on the beds in the neighbourhood of Geneva, says distinctly that the glacial beds with their erratics, which are greatly developed there, are superimposed on the so-called "alluvion ancienne," *i.e.* the stratum in which the Pleistocene animals occur; and he adds, "Nous n'avons pu decouvrir dans les environs de Genève aucune preuve de l'existence de deux epoques glaciaires."[1]

At Chambery in Savoy, some lignites have occurred in which although no Mammalian remains have been found, plant remains occur, showing them to be on the same horizon as the lignites of Dürnten and Utznach. Their age, says Mortillet, is perfectly established, they are anterior to the great extension of glaciers, whose products, clays, striated pebbles and erratic blocks overlie them. Mortillet continues thus: "Le lignite de Chambéry est tout à fait analogue, comme constitution et aspect physique, à celui des Cantons de Zurich et de St. Gall. Le gisement est semblable et tous les deux sont pré-glaciaires."[2]

---

[1] Bull. Soc. Geol. de France, ser. iii. vol. iii. pp. 659–660.

[2] Le Préhistorique, pp. 216, 217.

M. Mortillet discusses another instance of which much has been made, and which is a good example of the slight basis upon which interglacial theories have been built. This is an alleged intercalation of stratified "ancienne alluvion" between two glacial beds, in the gorge of the Drance, near Thonon (Haute Savoie). M. Mortillet says the Drance there cuts through some almost vertical calcareous beds; on the upturned edges of these beds there rest layers of alluvion, over which lie glacial beds. In some places in the gorge the calcareous beds have been denuded of their covering, and form a cornice; on to this cornice some of the glacial débris has slid down and made a kind of talus, looking at first sight as if it were overlain by the alluvion. The fallacy of this reading was tested by M. Mortillet, by making excavations on the spot,[1] when it turned out that there was no intercalation whatever, but that the alluvion lay always underneath the glacial beds.

If we turn from the northern to the southern flanks of the Alps we shall find precisely the same evidence. At Careguano, at Lanzo, near Stura, at Giffenga in the Valley of the Cervo, at Boca, at Maggiora and at Leffe (Gandino), there are certain lignites which are distinctly correlated by their Mammalian remains and other contents with the lignites of Utznach, Wetzikon, etc. Now it is a remarkable fact, as Gastaldi has shown, that these Italian beds rest directly upon Pliocene deposits and in no case, so far as it is known, do they have any glacial beds below them. The facts here quoted about North Italy have proved a stumbling block to Prof. James Geikie, who admits them, and admits that there are no traces in North Italy of former oscillations of climate (Geol. Mag. 1872, Vol. IX. p. 256). He calls in that modern *deus ex machina* denudation to explain it. It seems to me very plain, therefore, that in the Alpine regions of Switzerland and its neighbourhood, the evidence shows that the Mammalian beds do not overlie the Drift, but when they occur together they are always covered by them.

Let us now turn elsewhere. In the valley of the Inn, above Innsbruck at a place called Hötting, there is a breccia composed of stones from the Upper Triassic dolomite, of pieces of red sandstone, and of crystallized rock. This breccia contains remains of plant. Penck and others have declared this breccia to be underlaid as well as overlaid by moraine matter of glacial age, and the particular instance has been made much of by the advocates of interglacial mild periods. Unger and Stur, who have examined the plant remains, have found among them leaves of fan palms and other evidences of a tropical climate, proving the beds to be of Tertiary age, and therefore outside the possibilities of being interglacial. I feel convinced that in other cases where the drift has been supposed to underlie the Pleistocene land-surface that Tertiary conglomerates more or less disintegrated have been mistaken for it. The conclusion for which I am arguing is also supported by the evidence from the valley of the Rhone. Falsan, a most competent authority, writes as follows: "Durant nos études avec M. E. Chantre sur le terrain erratique du

---

[1] Le Préhistorique, p. 312.

basin du Rhone dans sa partie moyenne nous n'avons pas trouvé de traces de deux ou de plusieurs periodes glaciaires. . . . Nous avons été amené aussi à accepter qu'une seule période glaciaire d'une durée immense," and after granting certain oscillations he continues:—"Nous repoussons comme peu vraisemblable la theorie des récurrences de periodes glaciaires distinctes."

In regard to the Cavern of Chaleux on the Meuse, M. E. Dupont writes that the remains of man were deposited before the deposition of the yellow clay with angular blocks of limestone and the deposition of the Loess (Q.J.G.S. vol. xxiii. Translations and Notices, 3 and 4).

If we turn to North Germany we have an area where the facts are, as Mr. Geikie says, very difficult to read, from the very mixed contents of the beds, from the absence of natural sections, and from the absence also of true Till or Boulder-clay. The great mass of the drift beds consists of sand, which is not always easy to distinguish from the sands of the Brown Coal-formation. It is also very probable that in every case the Mammalian bones found in them are not *rémanié*. In regard to the shells, this is certainly so, for as Prof. Geikie says, they are not only much broken and abraided, but they are sometimes filled with a material entirely different from the matrix in which they are embedded, showing they are merely erratics, like the glaciated stones among which they occur.

A test of the difficulty of correctly reaching these North German beds may be gathered from the fact that some distinguished geologists, notably the Commission appointed by the National Geological Institute of Prussia, have quoted certain turf deposits in Lauenburg as evidence of an interglacial mild period. These beds were asserted by Keilback, in 1884 to be interstratified among glacial beds. They have recently been carefully examined by Credner, Gedinitz, and Waanschaffe, who have shown that the bed of turf in question is not intercalated as was supposed, but lies on the glacial beds. Movements of the soil and slippings have misled Keilback; for, where the section can be examined in tact, it shows a layer of marine sand containing a *Cardium* which previous observers have treated as of diluvian age, but which really belongs to the Miocene period, above which rests a calcareous sand, which is truly diluvian, and then the glacial marl. Above this rests the turf, containing lines of sand, above which there is no glacial bed whatever, and the turf with its sandy streaks everywhere overlies the glacial bed. The plants it contains are all still found in Lauenburg and the bed is really post-Glacial.

Turning to Scandinavia, the evidence is very scanty indeed. I know of only one case which is germane to our discussion. Peat, with palæolithic implements, and bones of the cave bear, is described by Nillsson as underlying the Jära wall, a great ridge of sea-gravel extending along the coast of the Baltic from Ystad to the part between Trelleborg and Falsterbo. "If this ridge be an åsar," says Mr. Geikie, "as from the description may be inferred, and should it prove to belong to the great åsar series, this would demonstrate that man had inhabited Sweden before the last great submergence and period of floating ice" (Geikie, Geol. Mag. 1872, Vol. IX. pp. 259 and 260).

In regard to Russia, Pander detected remains of Mammoth and Rhinoceros in reddish clay, covered by erratic blocks, eight versts to the south of Verchni Volotchok. . . . . In one spot, 300 versts south of St. Petersburgh, and twenty versts south of the river Kolomenba, M. Pander further found the horns of a Stag in gravel or drift, 21 feet below the surface, and covered by fine yellow sand, which is surmounted by clay and northern erratic blocks (Russia and the Ural Mountains, vol. i. p. 651*, postcript).

Sir Roderick Murchison himself has recorded the discovery of the bones of the Mammoth and Woolly Rhinoceros, near Moscow, in reddish clay, covered with erratic blocks, on the plains thirteen miles distant from the river (*Id.* 650). "If we follow," says Belt, "the northern drift southwards from Moscow, as I have done, we find it gradually changes from clay with boulders to the clay without boulders that covers the southern plains. Around the Sea of Azof, cliffs of this Glacial clay, 100 feet high, can be followed continuously for miles, and its junction below with the older beds is sharply defined. It rests on a freshwater deposit containing shells of species of *Unio*, *Cyclas*, and *Paludina*, and at this horizon fragments of the tusks and bones of the Mammoth are abundant, and are always undoubtedly older than the Glacial clay. In a similar position the same remains have been found at Odessa and other places in the south of Russia" (Belt, Quarterly Journal of Science, vol. vi. p. 290).

This survey of the European evidence does not profess to be exhaustive, but it includes, I believe, all the important examples upon which the theory of the post-Glacial or inter-Glacial existence of the Mammoth has been based. It seems to me that that theory, as tested by the European evidence, will not bear criticism, and that when Geoffrey St. Hilaire gave the Mammoth the name of *Dicyclotherium*, he was postulating for it, as many others have done since, a character which the evidence does not support.

Let us now shortly turn to America. In America the evidence seems to me to be very contradictory. The great deposits of bones contained in the so-called Salt-licks are outside the area occupied by the drift. Within the drift area most of the remains occur as sporadic bones, and they must be treated as erratics just as the tree trunks and logs which have been frequently found there imbedded in tough boulder-clay. When we come to test the problem, however, in the only adequate way, namely, by an actual undisturbed land surface of the Mammoth age containing bones, the evidence is very fragile and unsatisfactory. That the so-called dirt-beds and Forest-beds are covered by Till and in many cases by an enormous depth of Drift deposits is universally admitted. That so far as we know, they never occur at or near the surface except either outside the Drift area or where it has thinned itself almost out is also admitted. That above the true dirt-bed there very often occur logs and detached pieces of the bed which have been denuded and detached from it and which are found like boulders in the clay, sometimes such portions being several yards in size, is also true, but I have failed to find evidence of a Drift-bed underlying a dirt-bed *in situ.*

The very great majority of cases known, depend on such unsatisfactory evidence as well-sections. It is not wonderful, therefore, that there should be a feud among the American geologists as to the reading of the facts. The State geologists of Indiana recognize only one forest-bed, and declare that it *underlies* the Drift.

In Illinois the evidence is most unsatisfactory. I will give one of the most typical cases relied upon by Professor Geikie in his defence of interglacial beds. "In Perry County, Illinois, Mr. Worthen describes a bed of blue sand with leaves and sticks as occurring below the main mass of Drift. *This bed, he continues, usually lies at the bottom of the Drift deposits, but at one point in Jackson County* it was underlaid by *a bed of sand* two or three feet in thickness." It is assuredly a brave thing to postulate that the occurrence of a bed of sand is in itself evidence of the dirt-bed being underlaid by Drift. In Woodford County a similar accumulation of peaty matter was found at a depth of about 65 feet below 50 feet of *hard-pan.* In Ohio, Mr. Charles Whittlesea tells us how he had examined 59 wells in 1844, of which only six, or 10 per cent., showed traces of dirt-beds, leaves, timber, or silt. While he names several instances of logs of wood being found imbedded in the till, I cannot find any case where dirt-beds are stated by him to have been underlain by Drift, while all are stated to have been covered by deep beds of Drift.

Dr. Wright, "who has written so admirably on the glacial age in America, says a thorough study of the condition and distribution of the buried forests, bears strongly, as I cannot but think, against the complete separation of glacial epochs in North America."

Mr. C. R. Gilbert, a distinguished American geologist, says: "In America, where there is great activity in the investigation of glacial phenomena the evidence of a single interglacial period is cumulative and overwhelming, while there is no indication whatever of more than one." The American case as thus summed up is consequently completely at one with the European one; and it must be allowed, I think. that if there be here and there cases which appear to point to a different conclusion they are distinctly sporadic exceptions to a widespread law, and as such ought to be sifted and criticised with the greatest care and completeness, and that it is for those who still maintain a post-Glacial or inter-Glacial existence of the Mammoth to prove their case.

I have here and elsewhere in these papers used the words post-Glacial and inter-Glacial in their commonly accepted sense, as meaning that the Mammoth lived after the deposition of the Drift or lived between two such successive depositions. When I say that the facts inevitably point to the Mammoth beds when *in situ* always underlying the Drift, I do not mean that the Mammoth preceded the so-called Glacial age. I have written a very big book to try and show that it is contrary to the physical qualities of ice to suppose that it can move except under the influence of gravity, and that the theory of the distribution of the Drift deposits over hundreds of miles of level country by ice sheets is an hypothesis unsupported by experiment and at issue with the laws of ice movement so far as they are known. I do not believe, therefore, that the great sheets of gravel, clay, and sand, and the erratics connected with them were distributed, or can have been distributed by ice. I believe with the Fathers and Grandfathers of Geology, my Masters Murchison and Sedgwick, Hopkins and Phillips and Conybeare, Von Buch and D'Archiac, that the Drift, as we find it, was very largely distributed by water and not by ice; and when we find the Mammoth beds overlain by Drift, it means in my view not that the Mammoth lived before the so-called Glacial age, but that it lived before the diluvial movement which distributed the Drift, and which I think I have proved, in my work on "The Mammoth and the Flood," exterminated that beast and some of its contemporaries.

In my view the Glacial age was not an age of ice caps and ice domes and portentous ice sheets, nor of any other transcendental nightmares, but an age ot big glaciers occupying the mountain regions of half the northern hemisphere, and perhaps of all the southern one in the temperate zones. Alongside these glaciers there then existed, as there exist still in New Zealand, stretches of fertile country where the Mammoth and the Rhinoceros could live, where the oak and the fir could grow, where the contrasts of climate were not caused by difference of latitude, but by difference of elevation, and where, therefore, the Hyæna might well feed upon the Reindeer, as we know positively it did, where the Musk Sheep and the Pika could live along side of the Tiger and the gigantic Ox, as we know they did, and the polar willow could live upon the upper banks of a river whose lower one were occupied by the fig and the Canary laurel. The facts to be explained seem, to me, to inexorably demand this.

Professor Geikie, and other champions of extreme Glacial views, are willing to allow that the Mammoth lived in Siberia while the ice dominated Europe and North-Eastern America; I believe that it not only lived in Siberia, but in European Russia, in Northern and Central Germany, in France, and in South Britain, while the Mammoth and the Mastodon occupied very much the same country as the Buffalo did in later times in America. At the same time, Snowdon and the Grampians, the Vosges east of the Jura, and the Laurentian uplands, nourished large glaciers, while those of Norway and Switzerland, and the Cascade mountains, were much larger than any now to be found in those countries. Then came a great catastrophe, caused in all probability by the upheaval of some of the greatest mountain-chains of the world, of which I have published a great deal of evidence in these pages, and of corresponding subsidences elsewhere, about which I may perhaps be allowed to write on another occasion, and the direct result of this was the diluvial movement I have mentioned.

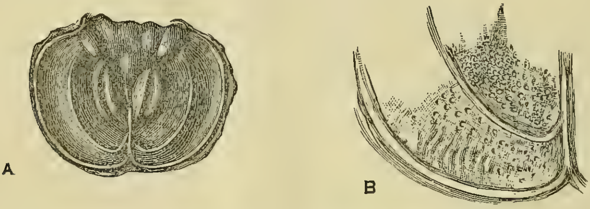
The story here condensed is, I believe, a logical story, and it is the only one which, so far as I know, explains the facts.

V.—NOTE ON A NEW BRITISH SPECIES OF *CYCLUS* FROM THE COAL-MEASURES OF BACUP, LANCASHIRE.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

SOME years since, Mr. Mark Stirrup, F.G.S., of High Thorn, Bowdon, Cheshire, placed in my hands a new form of *Cyclus* for examination. I had a drawing of it prepared, and made a note of it for future reference, but proceeded no further. That specimen is now in the Museum of the Owens College, Manchester, and by the kindness of Mr. W. E. Hoyle, the Keeper of the Collections, I am permitted to describe it in the GEOLOGICAL MAGAZINE.

The specimen was obtained by Mr. George Scott, from the "Gannister seam" of the Lower Coal-measures, Old Clough Colliery, Bacup, Lancashire, and shows the dorsal aspect of a small circular Crustacean (?) shield, about the size of a shilling, a figure of which is subjoined. (The ventral aspect adheres firmly to the matrix, and cannot be described.)



Cyclus Scotti, H. Woodw., sp. nov., Lower Coal-measures, Bacup, Lancashire.
A. Dorsal aspect of carapace (nat. size).
B. A portion of the left posterior border magnified to show ornamentation.

Specific description.—Shield, or carapace, nearly circular in outline, bilaterally symmetrical (25 millimètres broad by 20 mm. long), having a well-marked median ridge dividing the carapace in half for 8 mm. from the posterior border; posterior margin slightly indented or notched in the centre; the lateral and posterior margins of the shield encircled by a smooth raised rim, which stops short at the antero-lateral margin (which is slightly compressed where the rim terminates), the shield being truncated for a breadth of 12 mm. in front. There is evidence on the right side of a slight extension of the smooth margin of the shield extending beyond the outer raised rim. Anteriorly the shield is ornamented by four, nearly equal, oval, prominences, each being about 5 mm. long, placed two on either side of the central line,[1] with their longer axis directed towards the front of the shield; a well-marked, smooth, semicircular ridge occupies the centre of each lateral area, and unites with the raised median ridge near the posterior border of the shield.

The area enclosed between the outer and median ridges becomes considerably narrower as these approach the centre, near the posterior region of the carapace. The median ridge ends in front close to the outer pair of oval prominences; two other rather semicircular smooth raised ridges, broader and shorter than the preceding ridge (by which indeed they are encircled), occupy the inner and more central portion of the shield, the outer one commencing near to, and the inner one on, the central ridge, at 5 mm. distance from the posterior border, and curving forwards until they touch the posterior ends of the two pairs of oval prominences near the front of the carapace. In the centre, between these raised ridges and the oval bodies, is a small lozenge-shaped area, which is continued backwards till it unites with the median ridge of the shield.

---

[1] The two inner oval prominences have been *largely cut away* at some time in an injudicious attempt to develop the anterior part of the carapace.

The surface of the shield (particularly the posterior portion) is very finely granulated with minute circular and oval pustules (see woodcut, fig. B). No eye-spots are observable (unless a pair of the oval prominences in front may represent eyes? see woodcut, fig. A).

There is no trace of any appendages to be discovered on the matrix.

Observations.—Of the seven species of *Cyclus* already described by me, six are from the Carboniferous Limestone of Yorkshire and Ireland (see GEOL. MAG. 1870, Vol. VII. pp. 554–558, Plate XXIII.) and one from the Coal-Shales of Carluke, Scotland (see Brit. Assoc. Reports, 1868, p. 72, pl. ii. fig. 1, and *op. cit.*). Several specimens, not yet described, were obtained, many years since, from the pennystone ironstone, over the thick coal, of the Staffordshire Coal-field, at Coseley, near Dudley, by the late Mr. Henry Johnson, C.E., F.G.S., of Dudley, and will be shortly described by me.[1]

In general outline this species from Bacup resembles most nearly *Cyclus* (*Halicyne*?) *agnotus*, H. von Meyer, sp., from the Muschelkalk of Rottweil, Germany (see Palaeontographica, 1847, vol. i. p. 234, pl. 19, fig. 23), but it differs in having an indentation or notch in the posterior border, whereas the German specimen has a small prominence. The arrangement of the ornamentation of the shield is similar but still very distinct.

I have therefore no hesitation in treating this as a new species, and have named it *Cyclus Scotti*, after its discoverer, Mr. Geo. Scott, by whom it was presented some years ago to the Owens College Museum.

VI.—ON THE OCCURRENCE OF A TRILOBITE IN THE SKIDDAW SLATES OF THE ISLE OF MAN.

BY HERBERT BOLTON,
Assistant Keeper, Manchester Museum, Owens College.

THE series of slates, schists, and grits, of the Isle of Man, which are regarded as identical with the Skiddaw Slates of the Lake District, have hitherto yielded no traces of fossils, if we except the rare worm-like markings known as Palæochorda. The writer during the month of August last, took the opportunity of a visit to the island (in connection with the geological mapping by Professor Dawkins) to search very closely the least altered slates of the series along their northern outcrop.

After a barren search of several days, two specimens of Palæochorda and the fragmentary intaglio cast of a trilobite were found.

The specimens of Palæochorda call for no special mention, but the trilobite cast, notwithstanding its fragmentary condition, is of great importance, as giving a possible clue to the stratigraphical position of the slates in which it occurred, and also as demonstrating the existence of organic remains in what was formerly regarded as an unfossiliferous series.

---

[1] I regret to have overlooked Mr. B. N. Peach's paper on *Cyclus testudo*, Carboniferous series, Langholm. (See Trans. Roy. Soc. Edinb. 1883, vol. xxx. pl. xxviii. figs. 9–9*d*, p. 227.—H.W.

The specimen was found at Ballastowel, a hill crest overlooking Ramsey on the south-west, and lying midway between the familiar Albert Tower and Elfin Glen.

The Skiddaw Slates are here found dipping at an angle of about 45° to the north-west, and are a little contorted. They consist of an alternation of schistose slates, dark and but slightly altered slates and dark slates charged with well rounded quartzite pebbles.

Quartz veins pass in all directions through the series.

The trilobite cast was picked up from the scree immediately under the schistose slate and was evidently derived from that rock.

The following diagnosis of the trilobite has been obtained by the examination of a wax impression.

IMPRESSION OF BODY AND PYGIDIUM.

Thorax of six rings; axis convex and of uniform width; body rings narrow and well marked off from one another. Pleuræ very broad, twice the width of the axis; grooves deep, broadening towards the extremities, and disappearing a short distance from the axis; extremities directed backwards. Pygidium a little more than half the length of the thorax; width double the length; axis flattened, convex, and ending bluntly in the middle of the pygidium.

Observations.—From the presence of six thoracic rings, grooved pleuræ, and semi-circular smooth pygidium with feeble axis; the writer was inclined to class the specimen as an Æglina, but Dr. Henry Woodward has kindly pointed out that it differs from Æglina in the sides of the axis being parallel along their whole length, and in being convex, whereas in the former the axis diminishes in breadth from before backwards, and is flattened.

From a careful comparison of the specimen with others from the Cambrian of North Wales, Dr. Woodward is of opinion that it might with equal propriety be placed in the genus *Asaphus* as *Æglina*. Unfortunately the specimen is too distorted and fragmentary to settle the point. It is very probable that the specimen belongs to one of the two genera, and since both are markedly Ordovician or Lower Silurian forms, we may take it as evidence that the Skiddaw Slates in the vicinity of Ramsey, are of Arenig or Llandeilo age. This supposition is strengthened by the occurrence of two specimens of *Palæochorda* (an Arenig form) in the same beds.

The relation of the slates near Ramsey to the general series are difficult to determine until the mapping of the Island, now in hand by Prof. Dawkins, and the Geological Survey of Great Britain, is completed.

A traverse, however, made from Porth Mooar, the commencement of Messrs. Harkness and Nicholson's anticlinal,[1] to Ballastowel, a distance of three miles, showed the slates dipping to the north-west at a high angle (about 45°), so that a considerable thickness of slate must underlie those which yielded the trilobite. The thickness also of the overlying slates must be considerable.

---

[1] Harkness and Nicholson, Quart. Journ. Geol. Soc. vol. xxii. 1866.

The finding of the interesting specimen which we have described, in the midst of the Skiddaw Slates of the Isle of Man, will, we trust, stimulate research and lead to increased attention being paid to these beds.

VII.—THE GLACIAL SUCCESSION.

By R. M. DEELEY, F.G.S.

ALL students of British Glacial geology must feel that to Prof. James Geikie we owe much of our present knowledge concerning the Pleistocene succession in Europe; for he has not only been a zealous worker in the field, but has placed before us in a clear manner the valuable investigations of Continental geologists, with a view to showing how the succession that has been made out on the main land may be made to agree with that of our islands.

In a paper read before the Royal Society of Edinburgh last May, "On the Glacial Succession in Europe," we have his latest important contribution to this subject. No doubt when we have the promised new edition of the "Great Ice Age" in our hands, giving in detail the facts upon which he bases his conclusions, we shall be better able to appreciate the points he raises in this paper. Still the succession he has adopted is so clearly described, that in the absence of his more complete work, and even though he has not referred specifically to English deposits, I may, perhaps, be allowed to compare his results with those I gave in a paper read before the Geological Society in 1886.

Many geologists even now seem to be far from having come to a decision as to whether there really was any considerable alternation of warm and cold epochs during the Pleistocene period, nor can it be said that there is more than a general agreement in many cases between the successions made out by workers in different districts. We must, therefore, be content at present to state the opinions at which we have individually arrived, and by comparing the results so obtained strive to construct a true history of the Pleistocene period. That this can be accomplished there seems to be no doubt whatever; but whether it can be arrived at by a fuller appreciation of the facts now at our disposal, or whether it will result from future discoveries, remains to be seen.

I trust that it will not be supposed that I wish to deal with Professor Geikie's conclusions in a captious spirit, or that I wish to adversely criticise his conclusions; my object is really to place on record what I regard as a possibly correct correlation of the succession he has adopted with the one made out by myself, and also to refer to certain physical changes which have an important bearing upon the question of the age and formation of certain high-level shelly gravels.

Of course it is possible that I may have misunderstood Professor

Geikie's correlation of the Scottish deposits with those of England and Wales, for it was not necessary for his purpose to give us any facts, other than such as relate to the distribution of the Boulder-clays, so we cannot with certainty decide as to which English deposits he is sometimes referring. Still, from the localities he mentions, I judge that the "lower or oldest" Boulder-clay which "has the widest extension southwards, for it has been traced as far as the valley of the Thames," must be the Chalky Boulder-clay—that is one of my Middle Pleistocene deposits. This view is supported by his statement that "The Upper Boulder-clay, on the other hand, does not extend south of the Midlands of England." He here seems to refer to the Purple Boulder-clay, which is possibly of Newer Pleistocene age.

On p. 146 of his paper Prof. Geikie summarises in the form of an excellent table the succession he has adopted for Europe. This table I have somewhat abridged and placed alongside my own classification in such a way as to show their points of agreement and disagreement.

In this table he groups all the English Boulder-clays older than, and I suppose including, the Chalky Boulder-clay in his third group, or epoch of maximum glaciation. But there is yet an older glacial group mentioned, of the age of the Weybourn Crag, during which the ground moraine of the great Baltic glacier, underlying the "Lower diluvium" of Germany, is supposed to have been formed. Can this epoch be the equivalent of my Older Pleistocene epoch? Unfortunately the Boulder-clays and sands of this epoch occurring in the Trent Basin have not been traced into East Anglia. Their relationships with the Contorted Drift, White Sand, and Cromer Tills of Norfolk are therefore unknown, and it is impossible to say with certainty whether the Early and Middle Pennine Boulder-clays, and the Quartzose Sand are any of them as old as the Weybourn Crag, but what evidence there is seems entirely against such a supposition. We must, therefore, regard the deposits of Prof. Geikie's third group as belonging partly to my Middle Pleistocene and partly to my Older Pleistocene epoch, and regard such an early deposit as the Weybourn Crag as not being represented in the Trent Basin, but marking the commencement of the Older Pleistocene epoch.

From Professor Geikie's table it seems that he regards climatic changes as furnishing the most satisfactory basis for the classification of Pleistocene deposits; physical changes, such as have occurred in the distribution of land and water, not being made use of for this purpose. In fact the succession simply changes alternately from Glacial to Interglacial. Possibly this method of classifying the deposits may prove to be the best in the long run, although it is in striking contrast to that adopted for the older rocks. However this may be, in studying the deposits of the Trent Basin, it was found most convenient to base the divisions chiefly upon physical considerations, such as the abnormal condition of ice-flow which obtained at one time in the Midlands of England; an ice-flow which brought into the Trent Basin an assemblage of rock fragments quite unlike those which had been laid down by the earlier glaciers. I refer to the spreading of easterly and southerly rocks, such as chalk, flints, and Lias limestone and fossils over the older formations to the west and north-west, by an ice-flow which moved in a direction contrary to or across that of previous or subsequent ice movements.

In the Midlands of England the Older Pleistocene series consists of two thick deposits of tough Boulder-clay, separated from each other by a thick, false-bedded bed of sand or gravel. These deposits are not local, but on the contrary have been found retaining their lithological characteristics at such widely separated points as Gelston near Grantham, Leicester, Nottingham, Burton, and Ashbourne. The boulders are mainly of Pennine origin, but there are a few more distant erratics. Flint and chalk are quite absent, although the deposits occur within a few miles of the Cretaceous escarpment.

It has been suggested that these Older Pleistocene deposits were formed when the local glaciers entered the lowlands, and that the easterly rocks were thrust over them by the brushing aside of the local ice by the pressure of a great Scandinavian ice-flow. But the deposits themselves when examined in detail do not seem to support this view, for the line of demarcation between the two is quite sharp, and when the succession is anything like complete the Early and Middle Pleistocene Boulder-clays are separated by sands which clearly indicate open water. It only seems possible to account for this absence of local glaciers when the Scandinavian ice advanced over this country, on the assumption that it occurred during a period of submergence. It must be admitted that the opposition, just now, to such a view is very strong; an opposition, I think, based on very inadequate grounds.

During Older Pleistocene times the mountains of Great Britain stood well out of the sea, and as the climate became more and more severe the glaciers radiated from the hills, spread over the partially submerged low-lands, and deposited the great beds of non-flinty, silty, Boulder-clays, tills, and sands. In these silty clays, deposited long distances from the hills, the proportion of well striated stones is very large, indeed much larger than in the moraines formed in the mountain valleys. This arises from the fact that by the time the ice had reached the Midlands the glaciers in the hills had become so thick that very few cliffs were sufficiently high to shed stones on their upper surfaces; the transported rocks being mainly derived from the bed of the ice. It is quite possible that the British ice passed into the German Ocean and became confluent with the Scandinavian ice at this particular epoch; but, however this may be, it is quite certain that the Continental ice was unable to override what is now the Trent Basin.

At the close of the Older Pleistocene epoch the climate again became warmer, but in the succeeding Middle Pleistocene epoch cold conditions again supervened, but this time accompanied by a submergence. During this epoch it is possible the Moeltryfaen, Macclesfield, Gloppa, and Wicklow high-level shell gravels were formed. Owing to this submergence there seems to have been an absence of great glaciers in the British Isles, and the Scandinavian glacier passed unchecked up the easterly valleys of England towards the central watershed; for the Chalky Boulder-clay becomes a mere silt with an occasional flint in such sheltered places as Market Bosworth and Abbots Bromley. It must also be remembered that when the mountains of the British Islands were well out of the water and nourished great glaciers, the moisture-laden south-westerly winds would be precipitated in some measure before they reached the Scandinavian peninsula, whereas when these islands were partly submerged the precipitation would be on the continental uplands, and the Scandinavian glaciers would reach their greatest development. The chalky gravel which rests upon the chalky clay and encumbers all, or almost all, the southerly and westerly watershed of the Trent does not contain molluscan remains, although the ice-sheet of that date presumably passed over the floor of the German Ocean, yet to the west of the watershed, and in such straits as those of Silverdale and Biddulph, shell fragments are very numerous. Why, if the Scotch, Irish, and Cumbrian ice-sheet was able to form shell gravels at a height of 1360 feet in Wales, 1200 feet in Wicklow, and 1150 feet at Macclesfield, was it unable to form them in the central, south-eastern, and northern portions of the Trent Basin? And why was the Scandinavian glacier unable to form shell gravels in East Leicestershire? The gravels and sands are there in force, but not the shells. Rather the high level gravels of Wales are truly marine deposits, and the flints they contain were carried from the east by bergs carved from the Great Scandinavian Glacier which occupied the easterly valleys of England and not from Antrim. According to this view the gravels were formed partly during mild and partly during cold conditions of climate. One explanation of the absence of molluscan remains in the gravels to the east of the central watershed is that the Straits of Dover were not very wide, and that the northern part of the German Ocean was blocked by ice, leaving the enclosed area too brackish for mollusca to flourish in, and also that in interglacial times the German Ocean was dry land.

Professor Geikie's third epoch, a glacial one, would therefore seem to require further subdivision into five distinct epochs marked by a possibly continuous but varying depth of submergence. There is no proof, other than that furnished by the widespread nature of both the sands and Boulder-clays, and their marked lithological peculiarities, that these epochs indicate great climatic changes, but the evidence is distinctly in favour of such a supposition. From the table showing "The Glacial Succession" it will be seen that this means seven distinct cold epochs.

On the advent of warmer conditions, at the close of Middle Pleistocene times, Britain was again elevated, and the Trent began to deposit its high-level gravels, and clear out the Boulder-clays from its valley. Some of these gravels are between 70 and 80 feet above the alluvial plains of the present valley, and all terraces above about 30 feet show signs of great surface disturbance. From the trend of the ridges and furrows of these surface deposits the glaciers would appear to have come down the valley from the west rather than wholly from the valleys of the Derwent and Dove. There is no evidence to show that there might not have been several glaciers in Newer Pennine times. On this point I remarked, six years ago, "I have only been able to show the existence of one period of glaciation during this epoch, but there might have been two or even more, separated by considerable intervals of time." According to Professor Geikie there were three—his fifth, seventh, and ninth epochs. In these Later Pleistocene times the direction of the ice-flow was, as the surface disturbances show, again in accordance with the present local features of the country, the direction of the ice-flow which formed the Great Chalky Boulder-clay having been quite an abnormal one.

THE GLACIAL SUCCESSION.

OLDER PLEISTOCENE.		1. Weybourn Crag. Ground-moraine of Great Baltic Glacier.	Glacial.
		2. Forest-bed of Cromer.	Interglacial.
	Early Pennine B.C. Quartzose Sand. Middle Pennine B.C.	3. Lower Boulder-clays of Britain. Epoch of maximum glaciation.	Glacial.
MIDDLE PLEISTOCENE.	Melton Sand. Great Chalky B.C. Chalky Gravel.		
NEWER PLEISTOCENE.		4. Continental condition of British area.	Interglacial.
		5. Upper Boulder-clay of Britain.	Glacial.
	Interglacial Alluvium.	6. Britain again probably Continental.	Interglacial.
	Later Pennine B.C.	7. Ground moraines, terminal moraines, etc., of British mountain regions.	Glacial.
		8. Britain again probably Continental.	Interglacial.
		9. Local moraines in mountain valleys.	Glacial.

VIII.—GLACIAL GEOLOGY: OLD AND NEW.

By T. MELLARD READE, C.E., F.G.S., F.R.I.B.A.

THE NEW.

THE new school of glacial geology has found a champion in Mr. Percy Kendall, who, in ten pages of this MAGAZINE (November, 1892, pp. 491–500), attempts a reply to some of my criticisms.[1] Since then Dr. G. F. Wright's work, entitled "Man and the Glacial Period," has made its appearance, and in this Mr. Kendall is allowed 44 pages to explain his views of the glacial phenomena of the British Isles.

Mr. Kendall asks for "a clear exposition" of my views under no less than seven heads, at the same time stating that it would take two years' issue of this MAGAZINE, with no end of double numbers, to deal with them properly. Judging by the length of his reply and the ground covered by it, the estimate is no doubt a moderate one. I shall therefore, to save time and space, refer Mr. Kendall to the numerous papers of mine on glacial geology which, at his request, I some time since presented him with.

---

[1] Glacial Geology: Old and New, GEOL. MAG. July, 1892, pp. 310–321.

Mr. Kendall's reply deals only with two sections of the subject, viz., the Distribution of Erratics and the Molluscan remains. I presume they have been selected as his strongest points, and I was in hopes to have gained some important information in the way of facts that would be helpful in any honest attempt to interpret the phenomena. Instead of this I find that information well known to glacial geologists, through the labours of Mackintosh and others, including myself, trotted out as if it were new. These facts of distribution are, in my opinion, as I have frequently explained, quite irreconcilable with the Irish Sea Glacier hypothesis. Mr. Kendall seems to think that if he can show any grouping of boulders in the Boulder-clay, or indeed anywhere on the drift area, he has a sufficient answer to my criticisms; and in proof of this grouping he quotes as authorities the observations of geologists whose experiences are much newer even than the new geology. Although not prepared to accept Mr. Kendall's *ipse dixit* on the points either of grouping or proportionate distribution of erratics, I have not the slightest indisposition, for the sake of argument, to granting him all he states. It is perhaps not a sign of generosity on my part, for the reason that it does not, in my opinion, alter the bearing of the evidence at all.

It is admitted that Lake District rocks, together with Scotch rocks, are found in greater or less proportion all the way from Macclesfield to Moel Tryfaen. It has never been explained on the Irish Sea glacier hypothesis how they come to be distributed and intermixed over such a wide area, and this is the information I have in vain been seeking. In Dr. Wright's book it is very clearly shown (pp. 58–60) how the Alpine boulders found on the Jura were proved by Guyot to have been conveyed to their positions by a glacier. The proof was simple and convincing. All the boulders derived from the right side of the Rhone clung to that side, while all the boulders derived from the left side clung to the left side, and *neither the one nor the other crossed over.* If all the Lake District rocks were found in a trail from Cumberland to Macclesfield, and the Scotch rocks in a trail from Wigtown or Dumfries to Carnarvonshire *and none crossed over*, the Irish Sea glacier would "score." This is not the case; the rocks occur over the whole area even according to the new glacialists and are inextricably intermingled at all horizons according to my observations.

Until information is given which will harmonise these observations with the work of the Irish Sea glacier as conceived by its latest supporters,[1] it seems a waste of paper and printing ink to discuss any other points, especially bearing in mind the two years' lease of this Journal we are assured will be required for a full consideration of glacial phenomena.

---

[1] In this connection the communication from Mr. Deeley (GEOL. MAG. p. 573–4), is well worth studying.

Before, however, leaving the subject it will be interesting to examine the map of the British Isles in Dr. Wright's book, on which the lines of the Irish Sea glacier are laid down by Mr. Kendall—not in black and white, but in red. We have been prepared from time to time for the evolution this glacier has undergone to fit it to the new facts of glacial history as they arose, but I confess to feeling staggered at the "evolutions" it is put through, when I read the graphic description of what is euphoniously called the "Easting" of the Irish Sea glacier, and the production of the Solway glacier, by a cleavage which took place at Ravenglass by the pressure which forced it against the Cumbrian coast. "The 'Easting' motion carried it up the Solway Frith, its right flank spreading over the low plain of northern Cumberland, which it strewed with boulders of the well-known 'Syenite' (*granophyre*) of Buttermere." . . . . "Under the pressure of an enormous head of ice this stream rose from sea-level, turned back or incorporated the native Cumbrian glacier which stood in its path, and having arrived almost at the watershed between the northern and southern drainage, it swept round to the eastward and crossed over the Pennine watershed, not, however, by the lowest pass, which is only some 1400 feet above sea-level, but by the higher pass of Stainmoor, at altitudes ranging from 1800 to 2000 feet." . . . . "This Stainmoor glacier passed directly over the Pennine Chain past the mouths of several valleys, and into Teesdale, which it descended and spread out in the low grounds beyond." . . . . "The other branch of the Solway glacier passed up the valley of the Irthing and over into the Tyne, and out at sea at Tynemouth. It carried Scotch granites with it," etc.

These be "fairy tales of science," indeed, and we naturally ask ourselves on what is all this large superstructure of theory built? I confess I can find no satisfactory answer—it is beyond me, and Mr. Kendall does not help us. Grant whatever conditions may be asked for, especially such as no one has had experience of, and grant them in any required magnitude, and it is wonderful what engineering feats (in the imagination) may be performed.

For my own part I have been used to sober reality, and prefer the old fashioned careful weighing of evidence. When it becomes necessary to invent imaginary conditions to do imaginary work instead of rigorously reasoning out the probabilities of geological facts—all too few in many cases—I shall leave the seemingly congenial occupation to the poets and romancers of the science, and confess myself entirely unfitted for the prosecution of scientific investigation.

REVIEWS.

I.—A Catalogue of British Jurassic Gasteropoda. By W. H. Hudleston, M.A., F.R.S., Pres.G.S., and Edward Wilson, F.G.S. 8vo. pp. xxxiii. and 147. (London: Printed for and Published by the Authors, and Dulau & Co., 1892.) Price 7*s.* 6*d.*

A CONSIDERATION of the mass of Geological literature shows every year the greater need, not merely of indexing our knowledge but of tabulating the facts that have been accumulated. The mere catalogue of publications is valuable in its way to scientific workers, if brought out at regular intervals; but far more valuable are those works which, like the present one, summarize our knowledge on particular subjects.

The labour of cataloguing our British Fossils was for long in abeyance, until happily a start was made in the excellent Catalogue of British Fossil Vertebrata, by Messrs. Smith Woodward and Sherborn. We have much pleasure now in announcing the publication of another work that enumerates one group of British fossils—the Gasteropoda of the Jurassic rocks. This work, like the one before mentioned, is not a simple list of the known species, but a careful record of the well-established species, with full references to the original figures and authorities, and to the geological formations and principal localities. The nomenclature has been subject to critical revision, and all synonyms, as well as names of rejected and doubtful species, are noted in an appropriate manner. Such a work can only be adequately done by those having special knowledge; and in the present instance the work has been undertaken and accomplished by the highest authorities. Thus Mr. Hudleston has for many years made a particular study of the Gasteropoda of the Oolitic rocks, and the results of his labours have been published partly in this Magazine, and partly in the volumes of the Palæontographical Society; while Mr. Wilson has devoted himself more especially to the Liassic Gasteropoda, and his contributions on the subject are well known to readers of the Geological Magazine.

In their present work, the authors enumerate, in one list, all species from the Lower Lias to the Portland Beds; and they give a separate list of the Rhætic species, which "though not strictly Jurassic," are included, so as to indicate the scanty beginnings of the Jurassic Gasteropod fauna. These are supplemented by lists of Foreign species of doubtful occurrence in British strata, and of "species" not accepted. It will be noticed that the Purbeck Gasteropods are omitted, and we judge that this is due to the fact, that at present the species have not been fully worked out. Moreover the authors remark that, "The identification in British Jurassic rocks (below the Purbecks) of terrestrial and freshwater Gasteropoda in beds associated with marine bivalve and other fossils, cannot be unreservedly accepted without some strong confirmatory evidence." The species of *Helix*, *Hydrobia*, *Planorbis*, etc., that have been described are inserted with a query.

In glancing over the pages of this work, we are glad to find that comparatively few changes in nomenclature are introduced. We have been prepared for the abolition of the Jurassic *Phasianella*—the species are now included under *Bourguetia*; and also for the abandonment of *Eucyclus* in favour of *Amberleya*. *Chemnitzia* (so far as Jurassic species are concerned) remains almost wholly a Liassic genus; one species is retained for a Corallian form, but the Great Oolite species are queried, and others are mostly assigned to *Pseudomelania*. *Monodonta lævigata* becomes an *Ataphrus*. *Eulima*, *Pterocera*, *Scalaria* and some other genera are no longer recognized as Jurassic. Where subgenera have, for biological purposes, been introduced, they are placed in a subordinate position; as with *Ptygmatis* and *Nerinella*, which are arranged under the genus *Nerinæa*. *Euspira* likewise is included under *Natica*. This plan is eminently satisfactory to the geologist.

No attempt is made to indicate the zones in which species occur, and this would have been quite impossible, except in the cases of certain species obtained and described by the authors themselves, or enumerated by other authorities in recent years. Attention was not paid in old times to minute horizons, and even now-a-days the collector will find difficulty in obtaining *in situ* specimens that would satisfy the quite legitimate demands of the palæontologist. Sowerby described some of his species from Drift specimens; and we are glad to find that the authors, in assigning a locality to each species, have, so far as possible, given the first place to the type locality, or to the locality where a foreign species has first been noted in Britain. In future works of the kind it would be useful if the type locality were printed in italics.

With regard to questions of dates and priority the authors remark, "A person might spend the greater part of his life in hunting up such evidence as would be required to satisfy a court of law upon these points, which ought to be relegated to an international committee whose decision should be final."

The census given by the authors curiously enough records exactly 1000 species of Gasteropods from the Lias and Oolites, to which 15 may be added for the Rhætic species. About 150 doubtful forms are rejected.

The volume, printed as it is on thick paper, almost equals in bulk that of Morris' Catalogue, of which the second edition was published nearly forty years ago. Hence it may be judged that a complete Catalogue of British Fossils will now occupy many volumes. It is most satisfactory to note that the present work is brought out uniform in size and binding with the Catalogue of British Fossil Vertebrata.

We sincerely hope that others may now be stirred up to continue the good work which has been commenced, and so far carried out with such excellent results. Great labour, and a certain amount of drudgery, must always be incurred in preparing catalogues of this description. These however are not the most serious obstacles to the continuance of the work. Not every working palæontologist, who might be ready to assist, would be prepared to undertake the responsibility of publication. Authors may do their work as a labour of love; but publishers are usually animated by other motives. We must however state, that the issue of the Catalogue of Vertebrata, to which we have referred, owes much to the enterprise of the Publishers, Messrs. Dulau & Co. We fear that their laudable efforts have been attended by loss. In the present instance we believe the authors have undertaken the entire cost of publication. Geologists should bear this in mind, and even if they are not specially interested in Vertebrata and Jurassic Gasteropoda, they should cheerfully and readily support the undertaking, for only by so doing can the great work of cataloguing our British Fossils be successfully accomplished.

II.—THE JURASSIC ROCKS OF THE NEIGHBOURHOOD OF CAMBRIDGE. By the late THOMAS ROBERTS, M.A., F.G.S. 8vo. pp. 96. (Cambridge: at the University Press. London: C. J. Clay and Sons, 1892.) Price 3*s*. 6*d*.

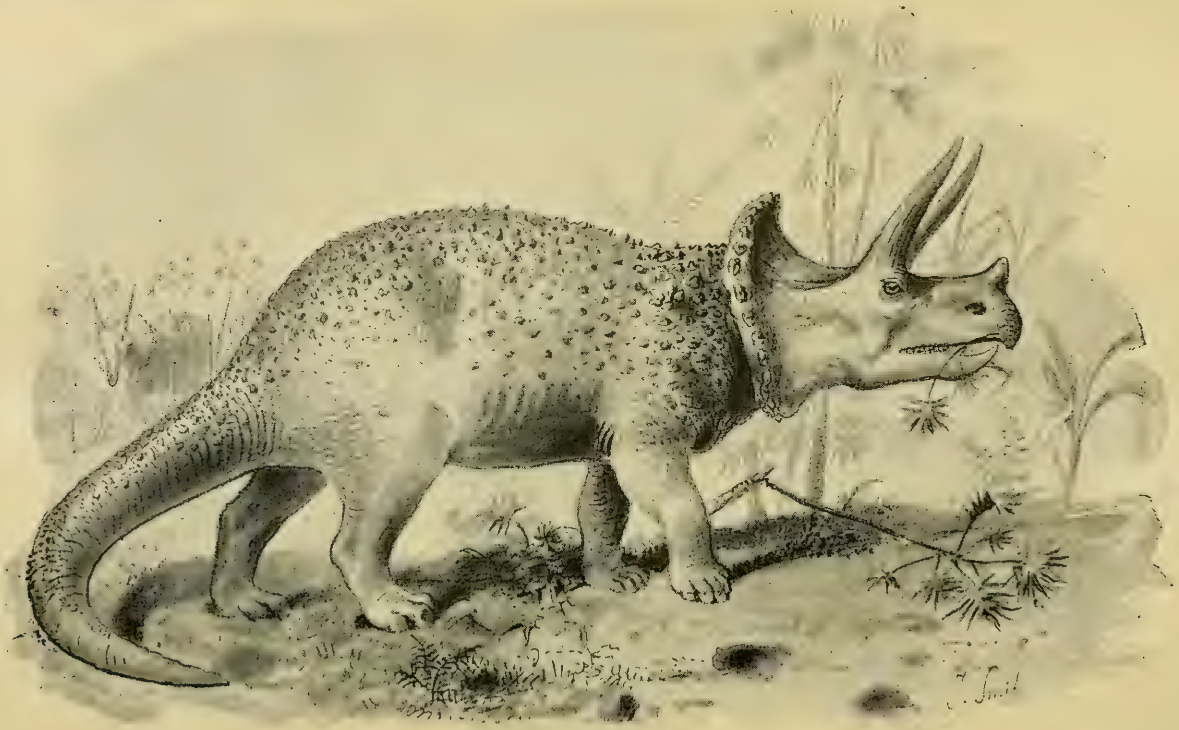
THIS work, which has been carefully edited by Mr. Henry Woods, serves as a fitting memorial of the labours of its author among the Jurassic rocks of the eastern-midland counties. It formed the subject of the Sedgwick Prize Essay for 1886, and has since been to some extent amplified; but the author, who had hoped still further to extend its scope, unfortunately did not live to see the accomplishment of this task.

The strata to which attention was directed are those from the Oxford Clay to the Kimeridge Clay, inclusive; and the main questions to be worked out related to the limits of the intervening Corallian division. A good deal of work was done, many years ago, by Prof. Seeley, and further information was gathered by Prof. Blake, Mr. Hudleston, and others; to whose labours and to those of other geologists due credit is given. Much remained to be done in working out the palæontological horizons or zones in this essentially argillaceous series of strata, for rock-beds are only occasionally developed, as at Upware, Elsworth, and St. Ives. To this work Mr. Roberts devoted especial attention, and most valuable results have followed.

In the Oxford Clay of the district he recognizes three well-marked zones, *in ascending order*, as follows (the figures should have been reversed):—

3. *Ammonites Duncani* and *A. Jason* (the *Ornati* group of Ammonites) of St. Neot's.
2. *Waldheimia impressa*, at the base of the St. Ives clay-pit.
1. *Ammonites perarmatus*, *A. crenatus* and *A. oculatus*, and the *Cordati* group of Ammonites, of the St. Ives clay-pit.

No beds so old as the Kellaways division of Wiltshire (zone of *Ammonites calloviensis*), are anywhere exposed. The fossils of the higher beds accord well with those known in other areas, but we question whether the zone of *Waldheimia impressa* can be regarded as more than a local sub-zone. It is noteworthy that *Ammonites Lamberti*, which occurs at this horizon elsewhere, and is sometimes



A GIGANTIC HORNED DINOSAUR TRICERATOPS PRORSUS. (MARSH.)

From "EXTINCT MONSTERS." CHAPMAN & HALL LD. 1892.)

taken as a zonal index, is not recorded by Mr. Roberts. He refers later on (p. 77) to the grouping adopted by Prof. Phillips, and remarks that the Oxford classification would apply equally well for the Cambridgeshire district. We may take it, therefore, that Mr. Roberts intended simply to indicate the local zones, without implying that they would be of general application.

Turning to the Corallian Rocks, a careful study of the fossils shows that the Elsworth and St. Ives Rocks are approximately of the same age, and that they represent, in part at any rate, the Lower Calcareous Grit of other areas; a conclusion that bears out the views expressed (with less confidence) by Messrs. Blake and Hudleston.

Overlying the Elsworth rock is the clay denominated Ampthill Clay, by Prof. Seeley, and this formation and its fossils are very fully described, so far as the area near Cambridge is concerned. The evidence goes to show that in mass this Clay represents the Upware Limestone, thus including both Coralline Oolite and Coral Rag. The general assemblage of fossils agrees in this view, which would include these beds in the zone of *Ammonites plicatilis*. The occurence together of *Ostrea deltoidea* and *Gryphœa dilatata* in the Ampthill Clay, serve also to connect it with the Corallian Rocks, for both species occur in those strata in Dorsetshire. Prof. Seeley had placed the Upware Limestone above the Ampthill Clay.

Another point of interest in Mr. Roberts' work, is the fixing of a plane of division between the Ampthill Clay and the Kimeridge Clay. Phosphatic nodules had previously been noticed in the Kimeridge Clay, but it had not been seen that they occur in a fairly constant manner at the base of it. The Lower Kimeridge Clay is well developed in the district, but the author has been unable to detect any Upper Kimeridge, unless it be in the uppermost part of the section at Roslyn Hill. The occurrence of *Ammonites biplex*, *Lucina minuscula*, *Discina latissima*, and other species, would seem to justify a more confident opinion with regard to the Upper Kimeridge; as is indeed held by Prof. Blake.

Concluding portions of this work deal with the Correlation of the strata with other English deposits, and with those in the Paris Basin, the Jura, and the neighbourhood of Hanover. The very full lists of species, all so carefully verified, from many localities and horizons in these Upper Jurassic Rocks, will render the work most valuable to all workers on the subject.

III.—EXTINCT MONSTERS: A POPULAR ACCOUNT OF SOME OF THE LARGER FORMS OF ANCIENT ANIMAL LIFE. By the Rev. H. N. HUTCHINSON, B.A., F.G.S., with Illustrations by J. SMIT and others. London: Chapman and Hall, 1892, 8vo. with 24 full-page Illustrations and 38 Illustrations in the text; pp. xx and 254. (Price 12*s*.)

MAN is distinguished from other animals by the higher development of his mental faculties, and one of the earliest lines along which his thoughts have ever delighed to travel, beyond the mere pursuits of his daily life, and beyond his capacities for loving and hating, is that of the embodiment of the wonderful and the mysterious. Nature in all her varied forms and moods speaks to the mind of man, as the nurse or parent speaks to the little child, and all her tales are full of strange and weird pictures.

The myths and traditions of all nations teem with marvellous accounts of monsters, grotesque or terrible, and it would seem as if those peoples who inhabited sea-coasts, or went down to the sea in ships, as the old Vikings and Norsemen used to do, or the ancient Greeks and more modern Chinese, always had the largest assortment of bogies of all sorts in stock. A glance at the deities of Egypt and of Ind, or at the pictured dragons of Japan, at the Centaurs, Harpies, Hydras, Chimæras, and Tritons of the Greeks, will show how the human mind has always delighted to revel in imaginary monsters, many of which were doubtless discovered by the priests of their various religions to be extremely useful to overawe and strike terror into the minds of the ignorant and superstitious masses.

It seems strange that whilst the active imagination of man in past ages was busy everywhere in *inventing* all kinds of marvellous and uncanny creatures, and often laboured hard to depict them graphically enough in stone, or bronze, or terra-cotta, there should have existed, tens of thousands of years before, in Europe, Africa, and America, and no doubt in Asia also, beasts more strange than ever the mind of man had conceived in his wildest moments of delirium or poetic fancy.

Of some of these once-living monsters the author of the present little work has ventured to give us a pictorial notion, assisted by his artist Mr. J. Smit and others; nor has his effort been wanting in success, and even if, in some cases the author and artist seem to have been less happy in making the dry bones live again, we must make due allowance for the many difficulties by which their self-imposed task has been surrounded. Imagine the dismay of a fashionable West-end tailor who should be ordered to outfit a Hottentot in elegant evening dress; or still more, to cut out garments for a gorilla! What wonder then if the combined efforts of author and artist have, in some instances, failed to make the artificial hides they have constructed fit gracefully on such incongruous beasts as *Triceratops* or *Stegosaurus*, or to induce *Brontosaurus* gracefully to tread the earth once more.

The pictures in Mr. Hutchinson's book,—which by the way do not include anything like all the monsters which we know almost completely at the present day,—have impressed upon us, more than any other work, the enormous advances which palæontological and geological discoveries have made in the past 35 years.

Let us for a moment recall the six crowded galleries of the old British Museum at Bloomsbury, into which were compressed not only all the then known fossil remains in the largest collection in this country both of Vertebrata and Invertebrata, but also the finest Mineralogical collection in the world, with the largest series of Meteorites preserved in any one Museum.

We remember the Ichthyosaurs and Plesiosaurs, the many odd bones of extinct reptiles, some of whose uncouth shapes Professor Owen had endeavoured to reconstruct, out of his inner consciousness, as the German Professor is said to have reconstructed the Camel. We recall the skeletons of the gigantic Irish Deer, the elephant-footed "Moa" from New Zealand, the *Megatherium americanum*, and the *Mastodon*; the skull of the *Sivatherium* and the Carapaces of the *Glyptodon* and the *Colossochelys.*

Turn now to the new galleries of the Natural History Museum, Cromwell Road, they are not *overcrowded*, although full; the Mineralogical Collection has a gallery 260 feet in length by 50 feet in width, entirely devoted to the display of this fine collection, whilst Geology is provided for in eight spacious galleries, far larger than any of those in the Old Museum. In the Geological galleries the gigantic Sloth from South America is seen climbing its tree, and near it a fine and perfect skeleton of the allied *Mylodon gracilis*, and a carapace of the *Glyptodon* with head, feet, and tail added. Instead of one "Moa" there are now six skeletons of these great extinct wingless birds. There is a nearly perfect skeleton of Steller's Sea-cow (*Rhytina gigas*), the largest of the Sirenia, and, alas! now quite exterminated since the year 1780. There is a complete restoration of *Tinoceras ingens* presented by Professor Marsh, from Wyoming Territory, with six horns on its skull; there are two skulls of *Brontops*; there are three skeletons of Gigantic Irish Deer; there is the *Archæopteryx*, the long-tailed fossil bird from the Oolite; there are also the *Dimorphodon* and the *Rhamphorhynchus*, both long-tailed forms of Pterodactyles, as well as many short-tailed forms. There is the original of the *Scelidosaurus Harrisoni*, a dinosaur from the Lias of Dorset, and the complete skeleton of *Pariasaurus Baini* from the Trias of South Africa; and, though we have only parts of many great Dinosaurs, yet, thanks to Prof. O. C. Marsh in America, and to M. Dollo in Brussels, we know what *Iguanodon* and many of the American Dinosaurs were like, and now we see them clothed in flesh by the author of the book before us, and we say advisedly, "there were monsters in those days" without a doubt.

We do not propose to discuss this book here. The author indulges in no rodomontade, but gives a careful and readable account of the wonderful discoveries which modern geological research in the Rocky Mountains, and in many other parts of the world, has brought to light. The twenty-four *full-page* illustrations are admirably executed, and there are thirty eight others in the text. There is a freshness about the whole thing which suggests "Alice in Wonderland." The book is a safe book to put into the hands of the young, and cannot fail to interest geologists of all ages. It will make an admirable and attractive New Year's book, which every one should buy and read for themselves.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 23rd, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "Outline of the Geological Features of Arabia Petræa and Palestine." By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

The region may be considered as physically divisible into five sections, viz.:—(i) The mountainous part of the Sinaitic Peninsula; (ii) the table-land of Badiet-el-Tîh and Central Palestine; (iii) the Jordan-Arabah valley; (iv) the table-land of Edom, Moab, and the volcanic district of Jaulân and Haurân; and (v) the maritime plain bordering the Mediterranean.

The most ancient rocks (of Archæan age) are found in the southern portion of the region; they consist of gneissose and schistose masses penetrated by numerous intrusive igneous rocks. They are succeeded by the Lower Carboniferous beds of the Sinaitic peninsula and Moabite table-land, consisting of bluish limestone with fossils, which have their counterparts chiefly in the Carboniferous Limestone of Belgium, and of a purple and reddish sandstone (called by the author "the Desert Sandstone," to distinguish it from the Nubian Sandstone of Cretaceous age), lying below the limestone. The Nubian Sandstone, separated from the Carboniferous by an enormous hiatus in the succession of the formations, is probably of Neocomian or Cenomanian age, and is succeeded by white and grey marls, and limestones with flint, with fossils of Turonian and Senonian ages. The Middle Eocene (Nummulitic Limestone) beds appear to follow on those of Cretaceous age without a discordance; but there is a real hiatus notwithstanding the apparent conformity, as shown by the complete change of fauna. In Philistia a calcareous sandstone in which no fossils have been observed is referred to the Upper Eocene; for the Miocene period was a continental one, when faulting and flexuring was taking place, and the main physical features were developed—*e.g.*, the formation of the Jordan-Arabah depression is referable to this period.

In Pliocene times a general depression of land took place to about 200–300 feet below the present sea-level, and littoral deposits were formed on the coasts and in the valleys. To this period belong the higher terraces of the Jordan-Arabah valley. The Pliocene deposits consist of shelly gravels. Later terraces were formed at the epoch of the glaciation of the Lebanon Mountains, when the rainfall was excessive in Palestine and Arabia.

The volcanoes of the Jaulân, Haurân, and Arabian Desert are considered to have been in active operation during the Miocene, Pliocene, and Pluvial periods; but the date of their final extinction has not been satisfactorily determined.

2. "The Base of the Keuper Formation in Devon." By the Rev. A. Irving, B.A., D.Sc., F.G.S.

In a paper published in the February number of the volume of the Quarterly Journal for the current year, the author definitely accepted the breccia which is clearly marked on the left bank of the Sid at Sidmouth as the base of the Keuper, but he had not then satisfactory data for determining a similar basement-line in the country between the valleys of the Sid and Otter, where the Keuper is repeated by the great Chit-rock Fault. Since then he has received information from the Rev. Dr. Dixon of Aylesbeare, mentioning the occurrence of breccia at several points on the east side of the Otter, and has subsequently visited the district, and with Dr. Dixon traced the breccia (the true base of the Keuper) along the left bank of the Otter, which for many miles seems to mark the western limit of the Keuper in Devonshire.

As results, (i) the palæontological difficulty which the occurrence of *Hyperodapedon* east of Ottermouth presented is now removed; (ii) the statement made in the last paragraph on page 71 of the author's paper in the February number of the Quarterly Journal needs some modification; (iii) the geological maps of the Devon area require considerable revision; (iv) data are furnished which enable us to estimate the thickness of the Upper Bunter at not more than about 100 feet; and (v) points of interest in the physiography of the country are indicated.

3. "The Marls and Clays of the Maltese Islands." By John H. Cooke, Esq., F.G.S.

The following deposits (in ascending order) occur in the Maltese Islands:—I. Limestone; II. *Globigerina*-limestone; III. Clays; IV. Greensands; V. Upper Coralline Limestone. The Marls and Clays forming the subject of this communication are No. III. of this list. They lie conformably upon the *Globigerina*-limestone, and so obscure is the line of demarcation between the two, and so striking the similarity of their fossils, that the clay may be considered as an argillaceous division of the formation upon which it rests. The upper part of the *Globigerina*-limestone is referred to the Hornerschichten of the Vienna basin, and the Clay to the Schlier. The separation between the clay and greensands is sometimes, though not always, complete, and occasionally the greensands are absent, and the coralline limestone rests directly on the clay. The thickness assigned to the clay by Dr. Murray (20 feet) is probably not far wide of the mark. A description of the lithological characters of the deposits of the clay division, based on microscopic evidence, is given. They consist largely of tests of foraminifera and minute fragments of minerals, and contain nodules of ochreous clay. A list of fossils of the clays is appended, including an addition of 31 species of Foraminifera to the 122 contained in Dr. Murray's list.

II.—December 7th, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.

The President announced that the American Philosophical Society will celebrate the one hundred and fiftieth anniversary of its foundation at Philadelphia, from May 22nd to May 26th, 1893. Fellows of the Geological Society who propose to be in Philadelphia during that week, and who may wish to participate in the celebration as representatives of the Society, are requested to communicate with the Assistant Secretary, Burlington House, W.

The following communications were read:—

1. "Note on the Nufenen-stock (Lepontine Alps)." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

In 1889 the author was obliged to leave some work incomplete in this rather out-of-the-way portion of the Lepontine Alps. In the summer of 1891 he returned thither in company with Mr. J. Eccles, F.G.S., and the present note is supplementary to the former paper. The Nufenen-stock was traversed from north to south, and a return section made roughly along the eastern bank of the Gries Glacier. Gneiss abounds on the north side of the Nufenen Pass, followed by rauchwacké and some Jurassic rock. On the flank of the mountain are small outcrops of rauchwacké and of the so-called "Disthene-schists" (both badly exposed), followed by much Dark-mica schist, often containing black garnets. Higher up is a considerable mass of Jurassic rock with the "knots" and "prisms" which have been mistaken for garnets and staurolites, but Dark-mica schists set in again before the summit is reached. They continue down the southern flank of the peak; but rather north of the lowest part of the water-shed, between Switzerland and Italy, the "Disthene-schist" is again found, followed by a fair-sized mass of rauchwacké.

The return section gave a similar association in reverse order; and both confirmed the conclusions expressed by the author in 1890 as to the absence of garnets and staurolites from Jurassic rocks (with belemnites, etc.), and the great break between these or the underlying rauchwacké (where it occurs) and the crystalline schists, in which garnets often abound, of the Lepontine Alps. The crystalline schists and the Mesozoic rocks are thrown into a series of very sharp folds, which, locally, presents at first sight the appearance of interstratification.

2. "On some Schistose 'Greenstones' and allied Hornblendic Schists from the Pennine Alps, as illustrative of the Effects of Pressure-Metamorphism." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The author describes the results of study in the field and with the microscope of (*a*) some thin dykes in the calc-schist group, much modified by pressure; (*b*) some larger masses of green schist which appear to be closely associated with the dykes; (*c*) some other pressure-modified greenstone dykes of greater thickness than the first. The specimens were obtained, for the most part, either near Saas Fee or in the Binnenthal.

These results, in his opinion, justified the following conclusions:

(1) That basic intrusive rocks, presumably once dolerites or basalts, can be converted into foliated, possibly even slightly banded, schists, in which no recognizable trace of the original structure remains.

(2) That in an early (possibly the first) stage of the process the primary constituents of the rock-mass are crushed or sheared, and thus their fragments frequently assume a somewhat "streaky" order;

that is to say, the rock passes more or less into the "mylonitic" condition.

(3) That next (probably owing to the action of water under great pressure) certain of the constituents are decomposed or dissolved.

(4) That in consequenc eof this, when the pressure is sufficiently diminished, a new group of minerals is formed (though in some cases original fragments may serve as nuclei).

(5) That of the more important constituents hornblende is the first to form, closely followed, if not accompanied, by epidote; next comes biotite (the growth of which often suggests that by this time the pressure is ceasing to be definite in direction), and lastly a water-clear mineral, probably a felspar, perhaps sometimes quartz.

(6) That in all these cases the hornblende occurs either in very elongated prisms or in actual needles.

The author brings forward a number of other instances to show that this form of hornblende may be regarded as indicative of dynamometamorphism; so that rocks where that mineral is more granular in shape (cases where actinolite or tremolite appears as a mere fringe being excepted) have not been subjected to this process.

3. "On a Secondary Development of Biotite and of Hornblende in Crystalline Schists from the Binnenthal." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

Both the rocks described in this communication come from the Binnenthal, and were obtained by Mr. J. Eccles, F.G.S., in the summer of 1891. They belong to the Dark-mica schists described by the author in former papers, and have been greatly affected by pressure. In each a mineral above the usual size has been subsequently developed. In the rock from near Binn this mineral is a biotite; the dimensions of one crystal, irregular in outline and having its basal cleavage roughly perpendicular to the lines indicative of pressure are about ·175″ × ·03″. The other mineral, from the Peak of the Hohsandhorn, is a rather irregularly formed hornblende, the crystals (which lie in various directions) being sometimes more than half an inch long. The exterior often is closely associated with little flakes of biotite. The author discusses the bearing of this fact, and the circumstances which may have favoured the formation of minerals, so far as his experience goes, of an exceptional size.

Some remarks also are made on the relation of these structures developed in the Alpine schists to the various movements by which these rocks have been affected, and on the general question of pressure as an agent of metamorphism.

4. "Geological Notes on the Bridgewater District in Eastern Ontario." By J. H. Collins, Esq., F.G.S.

The plateau of the Bridgewater district consists chiefly of gneiss and mica-schist, with subordinate beds of white marble, quartz-conglomerate and quartzite, and some veins of "giant-granite." The general dip of the gneissose series is eastward.

The author notes the effect of frost in splitting off flakes of the gneissose rocks and conglomerates, especially on the bare glaciated surfaces, and suggests that many of the smaller and shallower lakelets may have originated by this process.

The conglomerates are described as gneisses and mica-schists, with subordinate pebble-beds.

The occurrence of gold in quartz-veins near Flinders, and at Madoc, is noted; and amongst other economic products are the micas of the granites, asbestiform actinolite, and marble. The author discusses the mode of origin of the granite, marble, and actinolite-rock.

CORRESPONDENCE.

SELENOLOGY.

Sir,—Pressure of other work has caused me to overlook until now Mr. Peal's short but suggestive article in the last number of the Geological Magazine (Nov. 1892, pp. 500–502). Perhaps it may not be now too late to call Mr. Peal's attention to certain queries and suggestions published by myself in 1889 (App. ii. Note O, to my little work on "Metamorphism of Rocks"). I venture to think that some of these, suggested by an attempt to look at the matter from the chemico-geological standpoint, have hardly occurred to Mr. Peal. I will only note now two points: (1) that other tides than oceanic aqueous tides have to be allowed for; (2) that volcanic action is not under all circumstances dependent on water as an agent.

Wellington College, Berks, *25th Nov.*, 1892. A. Irving.

Sir,—The last paragraph of Mr. A. R. Hunt's letter (p. 573) is the most ingenious instance of misrepresentation by selective quotation that I have seen for a long time. Against such an antagonist I cannot contend. So I leave him to enjoy the illusion that particular difficulties are best solved by general ignorance (see paragraph three of his letter), and to metamorphose not only the rocks of Devon, but also my papers to his heart's content.

December 9th, 1892. T. G. Bonney.

MISCELLANEOUS.

Cambridge University.—Prof. A. H. Green, M.A., F.R.S., F.G.S, Professor of Geology in the University of Oxford, has just been elected an Honorary Fellow of Gonville and Caius College, Cambridge, of which he was an old student and a former Senior Fellow.

Professor Sir Richard Owen, K.C.B., F.R.S.—We regret to announce the death of Professor Sir Richard Owen, K.C.B., F.R.S., etc., which took place at Sheen Lodge, Richmond Park, at three o'clock, on the morning of Sunday, December 18th, 1892, in his 89th year. We hope to give a record of his life and work next month.

Your's always truly,

Richd. Owen.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. II.—FEBRUARY, 1893.

ORIGINAL ARTICLES.

I.—Sir Richard Owen, K.C.B., M.D., D.C L., LL.D., F.R.S., F.L.S., F.G.S., V.P.Z.S., Pres. Pal. Soc., Assoc. Inst. France.

(With a Portrait.)

IN recording the regret which the world of science feels at the loss of Sir Richard Owen, we seem to stand in a more intimate and personal relation to him than many others, from the fact, that he was not only one of the early and frequent contributors to the Geological Magazine, but also was the official colleague of the writer during a quarter of a century.

Born at Lancaster on the 20th July, 1804, Owen was destined for the Medical profession, and passed from school to college in Edinburgh, where he matriculated in 1824, passing his medical examinations and becoming a member of the Royal College of Surgeons in 1827.

About this time, his love of science was stimulated by a short residence in Paris, during which he attended the lectures of the illustrious Cuvier, then at the zenith of his greatness. After a brief period of private practice, he gladly accepted the position of Assistant-Curator of the Hunterian Collections in the College of Surgeons, conferred upon him on the recommendation of the celebrated Dr. Abernethy. Here he revelled in the examination of the uncatalogued preparations of Dr. John Hunter, the most distinguished surgeon of the last century.[1] He undertook the preparation of a series of Descriptive and Illustrated Catalogues of the specimens of Physiology and Comparative Anatomy; and later on, those of Natural History, Osteology, and Fossil Organic Remains preserved in the College Museum (1833–40). In 1834 Owen was elected to the Chair of Comparative Anatomy in St. Bartholomew's, carrying the title of "Professor;" and in 1835 married the daughter of Mr. William Clift, Curator of the Hunterian Museum, his old chief officer. In the following year he gained the fellowship of the Royal Society and the post of Hunterian Professor in the Royal College of Surgeons, which he held until his appointment to be Superintendent of the Departments of Natural History in the British Museum in 1856.

Whilst engaged upon the large series of Catalogues for the College of Surgeons' Museum, Owen obtained permission to dissect such animals as the Zoological Society's menagerie could from time to time supply, and this enabled him to contribute a long succession of most valuable papers to the Proceedings of the Society's Journal and elsewhere.

---

[1] In this task he was assisted by his life-long friend Mr. (now Sir James) Paget.

Valuable as are these memoirs, we naturally turn to Owen's palæontological labours as affording the matter of greatest interest to geologists.

Most interesting of these is his Monograph on the Fossil Mammals of the Mesozoic Formations (1871), which, although late in date, embodies much of his earlier work, and contains thirty species from British localities, such as Frome, Stonesfield, and Purbeck. This, together with his memoirs on the Red Crag Cetacea (1869); the Reptilia of the London Clay (1848–56, and 1880); of the Cretaceous Formations (1851–64); of the Wealden and Purbeck (1871–79); of the Kimmeridge Clay (1859–69); of the Mesozoic Formations (1873–77); forming a large series of Monographs, have all appeared in the annual volumes of the Palæontographical Society, embracing descriptions of 139 species of reptilia and nine species of cetacea.

Of his contributions to scientific societies it would be quite beyond the scope of this brief notice to give a detailed account.[1] His Memoir on the Pearly Nautilus appeared as early as 1832; his paper on a Belemnite from the Oxford Clay in 1844; his "History of British Fossil Mammals and Birds," in 1846; his "History of British Fossil Reptiles," 1849–51; his Palæontology in 1860, and 2nd Edition (1861). Among his Memoirs on foreign fossils may be mentioned that on the gigantic extinct sloth *Mylodon* (1842); on the *Megatherium* (in 1860); his series of Memoirs on the "extinct Marsupialia of Australia;"[2] the "extinct Birds of New Zealand;"[3] his memoirs on the *Archæopteryx*,[4] and the Dodo,[5] and on the fossil reptilia of South Africa,[6] are the most important. Of the twenty papers in this MAGAZINE the first appeared in 1865, and the last in 1883; the series form good examples of his short papers on palæontological subjects; and nearly every one is the description of some good fossil which had been brought to his notice.

In 1856, the question of the severance of the Natural History Departments of the British Museum was before Parliament, and after a prolonged discussion, Mr. Panizzi (aided, no doubt, by Lord Palmerston) held his position of Principal Librarian and *chief Executive Officer* of the British Museum, and Professor Owen was appointed Superintendent of the Natural History Departments, but without a separate administration. This enabled him to escape from all official routine, save one annual report, and signing the Keepers' monthly reports, and with now and then a special word of recommendation. He also gave a course of 12 lectures annually in the Lecture-Theatre of the Jermyn Street Museum; but only for a few years. This will explain why at this period of Owen's career, from 1856 to 1880, he was so prolific in papers and memoirs.

---

[1] The Royal Society's Catalogue of Scientific papers puts the number at 360; which does not include his works published separately.

[2] Phil. Trans. Royal Soc.

[3] Trans. Zool. Soc. London.

[4] *Ibid.*

[5] *Ibid.*

[6] Published by the Trustees of the British Museum.

The event of the Great Exhibition brought Owen (as the President of one of the Juries) under the notice of the Prince Consort, and he speedily became a recognised favourite with the Queen, and was frequently requested to deliver lectures on Natural History before Her Majesty and the Royal family. By the Queen's favour he received a residence, Sheen Lodge, Richmond Park, and a Civil List pension, both of which he enjoyed until the time of his death. He was President of the British Association at Leeds, in 1858; and was succeeded by the Prince Consort at Aberdeen, in 1859.

Although (away from Monte Carlo) every one is too well-educated to believe in "being born under a lucky star," nevertheless, we may safely affirm that Owen was born at a most fortunate time, and in a century marked by the greatest progress in science, commerce, and literature that the world has ever known.

Owen lived on into the new era of steam-locomotion, of telegraphs, of cheap printing, of good illustrations, of higher education; indeed, it is n t too much to assert, that Owen like his contemporaries, Herschell, Faraday, Lyell, and Darwin (together with many others), helped to bring on this great advance in civilization.

But for the vast amount of solid anatomical and palæontological work which Owen had accomplished, much of Lyell's work could not have been effected, and the theory of Natural Selection and the Origin of Species could not have appeared so soon. Indeed, when in the end of 1859, Darwin's first edition of the "Origin of Species" appeared, Owen claimed to have enunciated similar views *long before*. Nevertheless, when Darwin begged to be permitted to quote Owen as a supporter of his views, or as favourable to them, he declined to accept them, and classed them as a new phase of Lamarckianism which we should most of us live to see die a natural death. This was not generous, and contrasts strongly with Lyell, who having held to the old uniformitarian views for many years, and to the fixity of species, abandoned his old views, and accepted the new doctrines with an open mind.

The real secret, perhaps, lay in some anxiety felt by Owen lest he should lose popularity and give offence to the higher clergy, and to my lords, and (as the Catechism expresses it) "to those who are put in authority over us!"

The success that attended him in his long life resulted from a combination of circumstances. Everyone will readily admit the fact of Professor Owen's extraordinary genius, his sagacity in interpretation, and his remarkable ability as a lecturer; but behind these he owed very much to his indomitable energy and power of sustained work; to his marvellous flow of language, to his vigorous bodily health, and, in controversy, not a little to his cleverness both in defence and attack. His courteous manners, when dealing with the general public, were proverbial, and also the marked attention which he paid to the rank of the individual.

He was fortunate in belonging so early in the century to the medical profession, then standing almost alone as a body of most intelligent and able men of science (for the eminent chemists and engineers have arisen since). They could not spare time to criticize Owen's work, but they were as a body most generous and appreciative, and but few ever opposed him. He was happy in being appointed to the charge of the Hunterian Collections, for so many years kept back from publication by Sir Everard Home, who had promised to edit the Hunterian MSS. also, but failed to do so. Add to this his special opportunities and facilities for comparative anatomical studies, afforded by the Zoological Society; but most of all, to his choice of palæontology, then a virgin field of research, over which he was free to travel far and wide, and to reap for years golden harvests almost unchallenged by other workers. So unused was he to rivalry in his special lines of research that when younger men, like Falconer, Busk, G. R. Waterhouse, Huxley, and others, took the field, he became most keen to watch the "quarry," and when espied, even from afar, Owen eagle-like, would pounce upon and carry off the coveted spoil; indeed his whole nature seemed transformed in the presence of a new and undescribed fossil, so eager was he to take the field and describe it, or (as frequently happened) if the new discovery arrived at an unpropitious moment, he was equally eager to conceal his treasure from the curious and inquiring eyes of youthful aspirants.

It is pleasant to turn from the small struggles and weaknesses, which great men are apt, like lesser ones, to betray, and remember the solid advantages which Owen gained for us by long years of continuous and earnest work; even his very love of high and exalted personages has resulted in solid gain to science in the acquisition for the nation, through his persistent advocacy for twenty years, of the magnificent building in Cromwell Road, in which are now preserved the entire series of Natural History Collections, formerly overcrowded and inadequately housed in the old Museum Buildings in Great Russell Street.

This notice would be still further incomplete were we to omit to remember the fact that Owen was able to shake off his scientific aspect and become, at Sheen Lodge, the amiable host and the accomplished guide to the beauties of his own wilderness garden at the back of Sheen Lodge, or to the wider and more extensive charms of Richmond Park. As a raconteur Professor Owen was inimitable. He had delightful stories to tell of Thackeray, of the Emperor of Brazil (who came out from London to visit him at 7 o'clock in the morning), of the gracious visits paid him by the Royal family; of his winters spent in Egypt; one winter in the company of H. and H.R.H. the Prince and Princess of Wales. He would tell of his visit to Italy to attend the Scientific Congress at Bologna, his trip to Vesuvius, and his visit to H.M. Bomba, king of Naples (now happily dethroned and gone) : or of his visit to the Vicomte de Lastic, to secure for the Museum the grand collection of weapons, and human and animal remains from the cavern of Bruniquel in the Valley of the Aveyron.[1]

He loved to recall the series of Lectures given before the Queen in the "White Drawing Room" at Windsor, when he astonished the Venerable Dean of Windsor with the information that "tadpoles" turned into toads and frogs.

There too were pleasant meetings (not for the promotion of science but of harmony), both at Lincoln's Inn Fields, and at Sheen Lodge, and also at the houses of Dr. Farre, and Sir James Paget, when quartette parties met to discuss sweet music; when Owen and Waterhouse played on the violoncello and the violin, Mrs. Waterhouse and her daughter on the piano, whilst Paget, Farre, and others joined in. Alas! they are nearly all gone over to the great majority: into the land of the great departed, into the silent land—yet not silent are the memories of their survivors who can recall some of those pleasant meetings long ago.

Upon his retirement from office H.M. the Queen graciously conferred upon him the title of Sir Richard Owen, K.C.B., but in our memories he will still remain "Professor Owen."

With gradual decrease of his bodily powers, he passed away on the 18th Dec., 1892.

We stood by Sir Richard Owen's grave on December 22nd, in the quiet churchyard of the little village of Ham, where he was laid to rest, by his own desire, beside his loving and faithful wife.

To-day (January 21st) has witnessed one of the most representative gatherings of men of science at the Royal Society which has been seen for years. H.R.H. the Prince of Wales occupied the chair, supported by H.S.H. the Duke of Teck, Lord Kelvin, and Lord Playfair; Sir James Paget; Sir A. Clark; Sir Frederick Leighton; Prof. Huxley; Sir A. Geikie; Sir John Evans; Prof. Stewart; Sir William Flower, Mr. W. Percy Sladen, Dr. Günther, Mr. Carruthers, Mr. Fletcher, Prof. F. J. Bell, Mr. E. A. Bond, Mr. Thompson, Sir H. Acland, Prof. Michael Foster, Dr. P. L. Sclater, Mr. T. Bryant, Sir George Stokes, Sir Frederick Abel, Prof. T. R. Jones, and more than 200 others were present, to consider the desirability of commemorating, by some suitable memorial, the eminent services of Sir Richard Owen in the advancement of our knowledge of the sciences of Anatomy, Zoology, and Palæontology. The first proposition, that there be a memorial, was moved by Lord Kelvin, Pres.R.S., and seconded by the Rt. Hon. T. H. Huxley, F.R.S. The second, that the memorial be in the form of a marble statue, to be offered to the Trustees, to be placed in the Natural History Museum, which Owen did so much to establish, was moved by H.S.H. the Duke of Teck and seconded by Sir William Flower. Mr. P. Lutley Sclater moved that a Catalogue of Owen's works be also prepared and printed and given to each subscriber. Sir James Paget nominated the committee, and Mr. Bryant, President of the Royal College of Surgeons, seconded the motion. Sir Andrew Clark, President of the Royal College of Physicians, nominated the Executive

---

[1] For which see the Phil. Trans. Roy. Soc. for June, 1864, and Abstract, Geol. Mag., 1864, pp. 137–138.

Committee, and Sir John Evans, seconded the motion. Lord Playfair also spoke. Sir Henry Acland moved a vote of thanks to H.R.H. the Prince of Wales for graciously taking the chair and consenting to preside over the Executive Committee. Prof. Michael Foster seconded the the motion.

The speeches were all kindly, generous, and eulogistic, and admirably delivered. The Prince spoke in the kindest manner of Sir Richard Owen as a personal and valued friend. The subscription list is already making excellent progress, and everything promises success to the Owen Memorial. Sir James Paget is Chairman, Sir William Flower, Treasurer, and Mr. W. Percy Sladen Secretary.

The following are the titles of Professor Owen's contributions to the GEOLOGICAL MAGAZINE, 1865–1886:

Descriptions of some remains of an Air-breathing Vertebrate (*Anthrakerpeton crassosteum*, Owen) from the Coal-shale of Glamorganshire. (GEOL. MAG. 1865, Vol. II. pp. 6–8, Plates I. and II.)

Descriptions of portions of Jaws of a large extinct Fish (*Stereodus Melitensis*, Ow.), probably a 'Cycloid,' with 'Sauroid Dentition,' from the 'Middle Beds of the Maltese Miocene.' (*Ibid.* 1865, Vol. II. pp. 145–147.)

On a New Genus (*Miolophus*) a Mammal from the London Clay. (*Ibid.* 1865, Vol. II. pp. 339–341, Plate X.)

Review of P. J. Van Beneden's "Recherches sur les Squalodons," (*Ibid.* 1865, Vol. II. pp. 405–411.)

On *Macrauchenia Patachonica.* (*Ibid.* 1865, Vol. II. pp. 520–523.)

On a Genus and Species of Sauroid Fish (*Thlattodus suchoïdes*, Ow.) from the Kimmeridge Clay of Norfolk. (*Ibid.* 1866, Vol. III. pp. 55–57, Plate III.)

On a Genus and Species of Sauroid Fish (*Ditaxiodus impar*, Ow.) from the Kimmeridge Clay of Culham, Oxfordshire. (*Ibid.* 1866, Vol. III. pp. 107–109, Plates IV. and V.)

Description of part of the Lower Jaw and Teeth of a small Oolitic Mammal (*Stylodon pusillus*, Ow.). (*Ibid.* 1866, Vol. III. pp. 199–201, Plate X.)

On the Mandible and Mandibular Teeth of Cochliodonts. (*Ibid.* 1867, Vol. IV. pp. 59–63, Pls. III. and IV.)

Letter from Professor Owen. (*Ibid.* 1867, Vol. IV. pp. 424–425.)

On the Distinction between *Castor* and *Trogontherium.* (*Ibid.* 1869, Vol. VI. pp. 49–56, Pl. III.)

Description of a Great Part of a Jaw with the Teeth of *Stophodus medius*, Ow., from the Oolite of Caen in Normandy. (*Ib.* 1869, Vol. VI. pp. 193–196, Pl. VII.)

Supplementary Note to the above. (*Ibid.* pp. 235–236.)

Note on the occurrence of Remains of the Elk (*Alces palmatus*) in British Post-Tertiary Deposits. (*Ibid.* 1869, Vol. VI. p. 389.)

Notes on two Ichthyodorulites hitherto undescribed. (*Ibid.* 1869, Vol. VI. pp. 481–483.)

Notice of some Saurian Fossils discovered by J. H. C. Hood, Esq , at Waipara, Middle Island, New Zealand. (*Ibid.* 1870, Vol. VII. pp. 49–53, Pl. III.)

Letter from Prof. Owen. (*Ibid.* 1873, Vol. X. p. 478.)

On an Outline of the Skull, Basal View, of *Thylacoleo.* (*Ibid.* 1883, Vol. X. p. 289, Pl. VII.)

Letter from Prof. Owen. (*Ibid.* 1884, Vol. XXI. p. 286.)

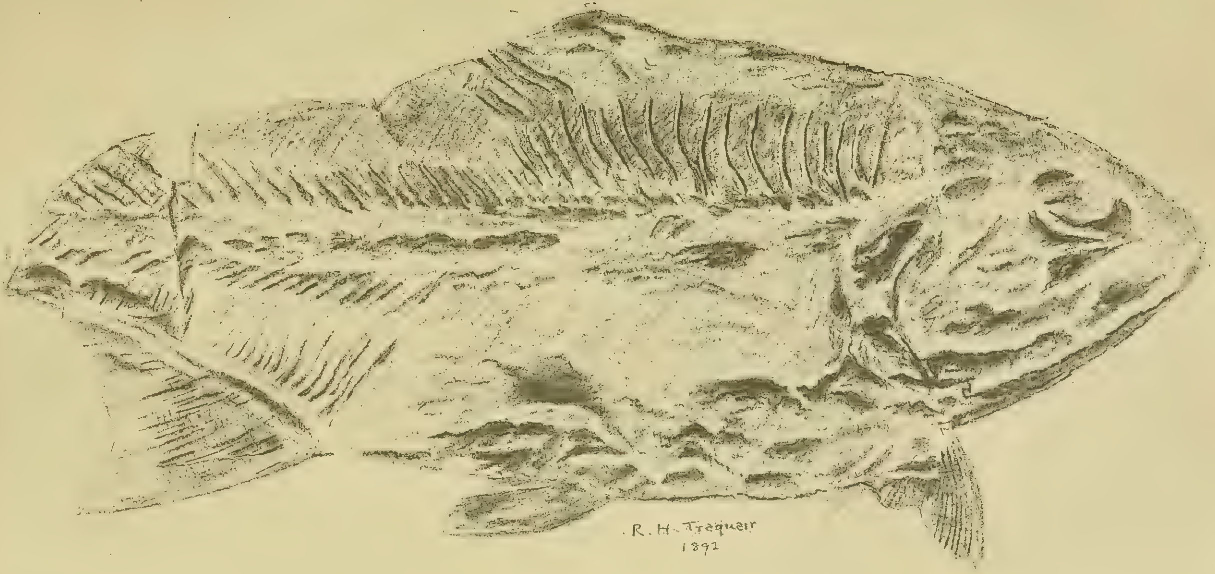
Letter from Prof. Owen. (*Ibid.* 1886, Vol. XXIII. p. 140). H.W.

II.—ON A NEW PALÆONISCID FISH, *MYRIOLEPIS HIBERNICUS*, SP. NOV. FROM THE COAL-MEASURES, CO. KILKENNY, IRELAND.

(PLATE III.)

By R. H. TRAQUAIR, M.D., F.R.S., F.G.S.

OF the fossil fish now described I know only two specimens, of which one is in the Manchester Museum, Owen's College, the other in the Museum of Practical Geology, Jermyn Street, London.



MYRIOLEPIS HIBERNICUS.—TRAQUAIR, SP. NOV.

Both are from the Coal-measures, Jarrow Colliery, Co. Kilkenny, Ireland.

The Manchester specimen (Pl. III.) is imperfect, being broken off about half an inch behind the anal fin; the dorsal fin is also deficient; but its position is indicated by the subjacent fin-supports. The pectoral, ventral and anal fins are present.

The measurements are as follows:—

Entire length of the specimen, so far as preserved ...	$7\frac{1}{2}$	inches.
From tip of snout to origin of pectoral fin	2	,,
,, ,, ,, ventral fin	4	,,
,, beginning of pectoral to beginning of ventral...	$2\frac{1}{4}$	,,
,, ,, ventral to beginning of anal ...	$1\frac{7}{8}$	,,
Depth of body at origin of ventral fin	3	,,
Length of head to posterior margin of gill cover ...	$2\frac{1}{4}$	,,

The head shows scarcely any detail, though it is at once apparent that its structure was typically Palæoniscoid, with anteriorily placed orbit, oblique suspensorium, and wide gape. Its length is contained $3\frac{1}{2}$ times in the total up to the tail pedicle, where the specimen is broken off.

The rather deeply fusiform body is shown to have been covered with rhombic scales which were exceedingly small in proportion to the size of the fish, those in the front of the flank measuring only $\frac{1}{20}$ inch in height and breadth; only feeble traces of a striated ornament are observable on them. Some large median scales are seen in front of the dorsal fin.

The scales must also have been very thin, as they have allowed the contour of the bones of the internal skeleton to be tolerably distinctly indicated through them—these indications being in the form of impressions of vertebral arches and spines, and of interspinous bones or fin-supports. The skeleton as thus exhibited is typically palæoniscoid.

The fins which are preserved are of moderate size, even small for the size of the fish. The pectoral is not completely shown, though enough is preserved to show that it consisted of numerous, fine, closely set rays which were also closely articulated, the principal rays being also jointed up to their origins. The ventral fin is small and narrow, with fine rays of a character similar to those of the pectoral. The anal is triangular-acuminate, its hinder margin somewhat concavely excavated, and consists likewise of numerous fine, closely-set rays, whose transverse articulations are extremely close. The dorsal fin is not preserved, but judging from the position of its supporting ossicles, it must have occupied a position nearly opposite the interval between the ventral and anal.

The specimen in the Museum at Jermyn Street, London, represents a slightly larger specimen, the length from the front of the head to the posterior termination of the base of the anal fin being $8\frac{1}{2}$ inches. Here the specimen is broken off, nearly at the very place where the same has happened to the specimen at Owen's College. However, the dorsal fin is preserved and shows a contour and structure similar to those of the anal in both specimens.

There can be no doubt that this fish is new to science as a species, the only question remaining for consideration is that of the genus to which it should be referred. The Carboniferous genera to which it seems most closely allied are *Elonichthys* and *Acrolepis*; but it is excluded from both by the very small size and thinness of the scales, and more especially from *Acrolepis* by the rays of the pectoral fin being articulated to their origins.

So far as the smallness of the scales and the arrangement of the fins is concerned, there is a very considerable resemblance between the present fish and the early Mesozoic genus *Myriolepis*, as described originally by the late Sir Philip Egerton,[1] and more recently by Mr. A. Smith Woodward.[2] But the condition, as to articulation, of the rays of the pectoral fin of *Myriolepis* does not seem yet to be known, and should its principal rays turn out not to be articulated up to their origins as in the present fish, there is little doubt that a new genus must be constituted for the reception of the latter.

Though it does strike one as slightly improbable that the same genus of Palæoniscidæ should persist from Carboniferous to Triassic times, I feel the setting up of new genera in this already most extensive family without absolute demonstration of its necessity becoming more and more distasteful. I therefore refer this interesting Irish Carboniferous palæoniscid to the genus *Myriolepis*, under the name of *M. Hibernicus*, though it must be distinctly understood that this reference is only provisional and awaiting confirmation, or the reverse, by the further development of our knowledge of the type species of the genus.

My thanks are due to Prof. Boyd Dawkins and Mr. Hoyle for the opportunity of examining and describing the specimen of this very interesting Carboniferous fish, which is preserved in the Museum at Owen's College, as well as to Sir Archibald Geikie for permission to examine that at Jermyn Street.

EXPLANATION OF PLATE III.

Myriolepis Hibernicus, Traquair, Coal-measures, Kilkenny, reduced one-fifth.

III.—On *Palæosaccus Dawsoni*, Hinde, a New Genus and Species of Hexactinellid Sponge from the Quebec Group (Ordovician) at Little Métis, Quebec, Canada.

By George J. Hinde, Ph.D., F.G.S.

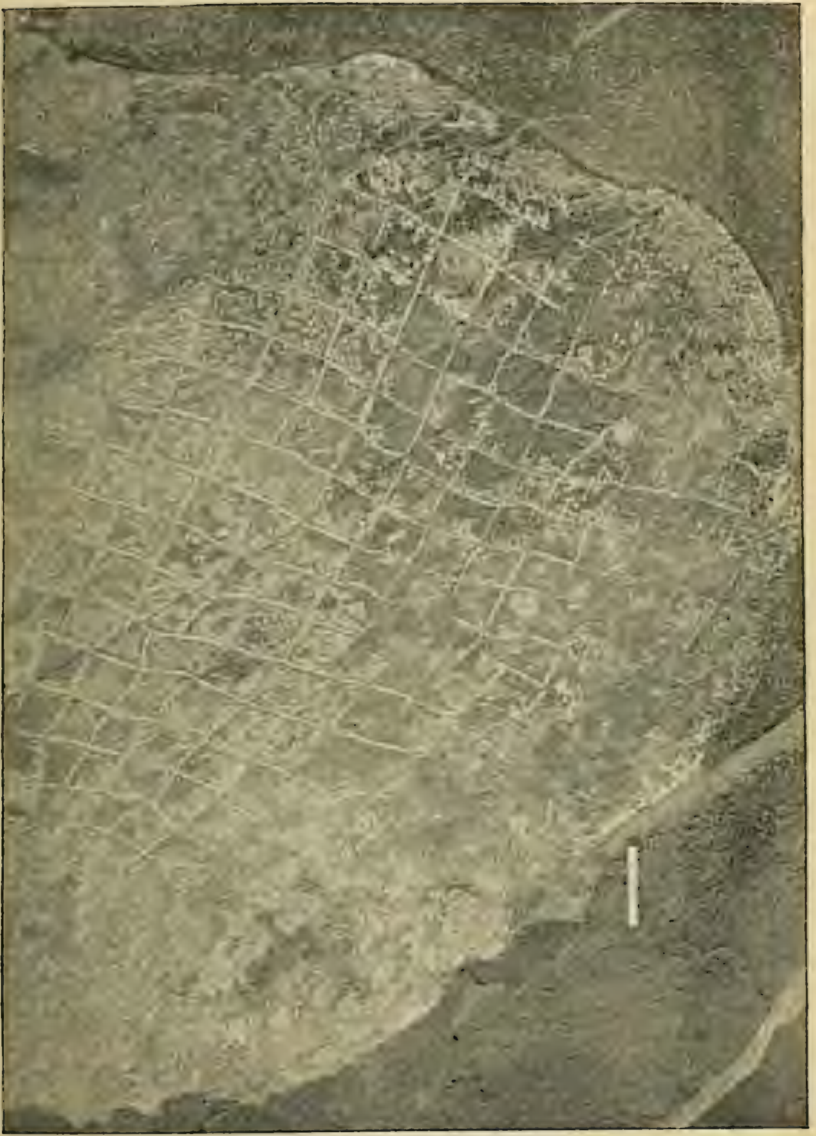
(PLATE IV.)

In 1887 and 1888, Sir J. W. Dawson discovered in dark carbonaceous shales of the Quebec group, exposed at Little Métis, on the north shore of the Lower St. Lawrence, some thin bands of rock largely filled with the remains of siliceous sponges, and similar fossils were found to be sparsely scattered in adjacent beds through a vertical thickness of forty feet. This discovery of an abundant sponge fauna at so low an horizon, in rocks previously considered

---

[1] Quart. Journ. Geol. Soc. 1864, vol. xx. p. 2.

[2] "The Fossil Fishes of the Hawkesbury Beds at Gosfort" (New South Wales), pp. 7–11.



Palæosaccus Dawsoni, Hinde.

A New Genus and Species of Hexactinellid Sponge from the Quebec group (Ordovician), Little Métis, Canada.

Reduced to $\frac{3}{7}$ the diameter.

to be unfossilliferous, proved to be of considerable importance in showing the character of these organisms which flourished at this early epoch, and though the condition of the specimens was far from perfect, Sir J. W. Dawson was enabled from the materials obtained to describe eleven new species, which were placed in the genera *Protospongia*, *Cyathospongia*, *Acanthodictya*, *Hyalostelia*, *Lasiothrix*, and *Halichondrites* (Trans. Royal Soc. Canada, vol. vii. section iv. 1889, pp. 31–55, pl. iii.). With the exception of the species referred to the three last-named genera, of which the relationships are at present doubtful, these sponges belong to the group of Lyssakine Hexactinellids, of which the earliest traces are found in the Cambrian strata of this country and elsewhere.

Since 1888, Sir J. W. Dawson has improved the opportunity afforded by passing the summer vacation in Little Métis in energetically working at fresh excavations in the beach and cliff sections at that place, with the result of obtaining many fresh specimens, which confirm the characters of the forms already described. This last summer his search was further rewarded by finding a specimen of a new and very distinct form, which he has done me the honour to entrust to me for description. As is the case with all the other sponges preserved in these black shales, this specimen is now in a flattened or compressed condition on the surface of the rock, and has the general appearance of a piece of coarse open network. Unfortunately the entire specimen could not be secured, and the portion on the slab, shown in the accompanying photograph, which has been reduced to about $\frac{3}{7}$ the diameter of the original, probably represents less than one-half of the whole form. The original siliceous structure of the skeleton has now been replaced by pyrites, so that the form and dimensions of the spicules are but imperfectly shown. The same mineral change has affected all the other sponges in these beds, and, in fact, it is of very general occurrence wherever siliceous sponges are embedded in similar black carbonaceous shales. The specimen evidently belongs to a new genus, which is proposed below.

PALÆOSACCUS,[1] gen. nov.

Cylindrical or sack-like sponges, with thin walls of rhombic meshes. The strands of the mesh-work consist of fascicles of slender rods, cruciform, and, perhaps, five-rayed spicules; the interspaces are either open or covered with a thin layer of irregularly disposed rods and cruciform spicules. No anchoring spicules have been found in immediate connection with the sponge, but there are in the same beds elongated anchoring spicules with ornamented spiral ridges which may perhaps belong to it.

From *Cyathophycus*, Walcott (=*Cyathospongia*, Dawson, non Hall), which appears to be nearest allied, this genus is distinguished by the rhombic character and large size of the mesh-work; the generally similar structure both of the longitudinal and transverse strands of the mesh, and the greater development of rod-like spicules. The same features likewise differentiate it from *Plectoderma,* Hinde, and *Phormosella,* Hinde.

---

[1] *παλαιος*, ancient; *σακκος*, coarse cloth, sack, strainer.

PALÆOSACCUS DAWSONI, sp. nov. (Pl. IV.).

Sponge of large size, apparently cylindrical in its complete form; the part preserved consists of a flattened portion of the wall-surface more than a foot in diameter; both the upper and the basal portions of the sponge are wanting. The rhombic meshes of the wall vary from 14 to 20 mm. in width, the average width is nearly 17 mm. The strands of the mesh mostly consist of very slender rod-like threads apparently simple, which are loosely arranged, generally parallel with each other. At the angles of the mesh there are, very frequently, if not in all cases, stouter cruciform, or perhaps five-rayed spicules, and slender cruciform spicules are likewise intermingled with the rods in the strands. In the interstices of the mesh-work, and apparently exterior to it, there is, in some portions of the sponge, a thin open layer, composed of slender rods and cruciform spicules, overlapping each other without definite arrangement. It is possible that this layer may have formed the outer surface of the sponge, for the spicules are of the same character as those of the strands of the mesh, but on this point there is some uncertainty, for the interstices in some parts of the wall are now quite open, and without this spicular layer.

Some uncertainty also arises respecting the anchoring appendages of the sponge, since the basal portion is wanting, and no anchoring spicules are found in immediate contact with the specimen, but on the surface of the same rock-bed in which it occurs, there are some peculiarly ornamented spiral rods which may belong to this species. Sir J. W. Dawson has given a diagrammatic representation of one of these spicules (*op. cit.* p. 49, fig. 20) which appears as if it consisted of several very minute filaments spirally twisted together, like the strands of a rope. Each filament has a row of projecting tubercles which in the rod are definitely arranged in quincunx, so that the general ornamentation is very striking. At the distal end the rods are slightly curved, and the raised lines are straight instead of spiral. As with the other spicules, these anchoring forms are now of pyrites, and it is not easy to decide whether they result from the amalgamation of slender strands or whether the spiral tuberculated ridges are merely the surface ornaments of a single rod-like spicule. Be this as it may, we cannot as yet state positively that these peculiar anchoring spicules really belong to the present species.

So far as can be at present determined this sponge appears to have consisted simply of a delicate thin sack or cylinder of spicular strands forming a rhombic mesh, with possibly a thin outer spicular layer. There is no evidence that the sack inclosed an inner spicular tissue, and probably this thin wall represents its entire skeleton. A similar condition seems to have been present in *Protospongia*, *Cyathophycus* and probably also in *Dictyophyton* and the genera allied to it, but in none of these do we find the structure on such a large scale as in the present form.

I have much pleasure in associating the name of this remarkable sponge with its discoverer, Sir J. W. Dawson, F.R.S.

Distribution.—Shales of the Quebec Group, probably near the base of the Lévis Division, at Little Métis, Lower St. Lawrence, Province Quebec.

EXPLANATION OF PLATE IV.

Palæosaccus Dawsoni, Hinde; a portion of the mesh-work of the sponge-wall exposed on the surface of a slab of black shale. Reduced to $\frac{3}{7}$ the diameter. From the Quebec Group (Ordovician) at Little Métis, Canada.

IV.—On the So-called Spilites of Jersey.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.,
and Miss Catherine A. Raisin, B.Sc.

About one quarter of the Island of Jersey is occupied by argillites or fine grits, often of a greenish grey colour referred by French geologists to the "Phyllades de St. Lo." They are, therefore, if not equivalent to the Lower Cambrian beds of Britain, slightly more ancient.[1] In close association with these, but according to Prof. de Lapparent, belonging rather to the upper part of the group, occur certain more or less porphyritic rocks, as to the origin of which different opinions have been entertained. M. Noury in his useful "Géologie de Jersey" describes them under the name of "spilites." While admitting that in many respects they exhibit the characters of an eruptive rock, he concludes, after an elaborate discussion, that they are metamorphosed argillite, the change being primarily due to the "porphyres pétrosiliceux;" the felspar crystals, however, he thinks, may be attributed to the action of the diorite.[2] Prof. de Lapparent, in a paper published in 1884, briefly refers to these "spilites" as amygdaloidal melaphyres; and again, in 1891, expresses the opinion that they are igneous rocks (tuffs, breccias, etc.), calling them porphyrites.[3] But as the point is one of considerable interest, the notes and conclusions arrived at in the summer of 1888, by one of the writers, may be worth placing on record.

A few words are needed to explain the delay and the joint authorship of this paper. Prof. Bonney in 1888 had the advantage of spending a week in Jersey in company with the Rev. E. Hill, who has added so much to our knowledge of the Channel Isles.[4] They examined with some care the mass of "spilite" at Mont de l'Ouest,[1] close to St. Heliers, for they felt doubts as to the correctness of M. Noury's view of its origin, and were struck by its occasional resemblance to some of the rock at Bardon Hill, Leicestershire, on the study of which they were then engaged. In hopes that it might throw light on some of the difficulties presented by that rock, specimens were collected, slides from which were examined by Prof. Bonney soon after his return to England. So far as concerned the immediate purpose the result was disappointing, for the resemblances proved to be comparatively superficial and the structures presented few difficulties. He was, however, convinced that M. Noury's interpretation was erroneous. A brief notice would have been published almost immediately, but more pressing work has again and again obliged him to leave the slides untouched in his cabinet, for want of time to search through the literature of the subject and to study the more minute microscopic details. So they would be still lying, were it not for the kindness of Miss C. A. Raisin, who has undertaken that, the more laborious part of the work.

---

[1] Bull. Soc. Géol. de France, vol. xvi. p. 412, A. Bigot; and Bull. du Lab. de Géol. de la Faculté des Sciences de Caen., A. Bigot, December, 1890, p. 11.

[2] Géologie de Jersey, 1886, M. Noury, pp. 59, 61, 63.

[3] Bull. Soc. Géol de France, 1884, tome xii. p. 288; Q.J.G.S., 1891, vol. xlvii. p. 36; Comptes Rendus, 1890, vol. 111, p. 543. After the completion of the manuscript of this paper, we received a copy from Prof. de Lapparent of his newly published "Note sur les Roches Eruptives de l'Ile de Jersey" (Ann. de la Soc. Scientif. de Bruxelles, tome xvi. 2^e^ partie) in which these "spilites" are described. But as he refers chiefly to other quarries and enters on the whole into fewer details than we have done, the results of our work may be still of some little interest, at any rate to English readers.

[4] Q.J.G.S. 1884 vol. xl. p. 404; Q.J.G.S. 1887 vol. xliii. p. 322; Q.J.G.S. 1889 vol. xlv. p. 380; Q.J.G.S. 1892 vol. xlviii. p. 122.

In the walls of gardens on the northern outskirts of St. Heliers blocks of "spilite" are common, one being a conspicuously porphyritic variety. In this, crystals of plagioclase felspar, rather tabular in shape, sometimes about $\frac{3}{4}''$ in length, occur in a dark purplish matrix. Prof. Bonney was informed that this variety was obtained from a quarry situated, as nearly as he can place it, on the east side of a valley to the south-east of the Town Mills Road, which is now enclosed and converted into a very pretty shrubbery to the grounds of a villa. He was unable to procure a specimen, but the rock appeared only to differ from some of that about to be described in the rather greater size of the felspar crystals.

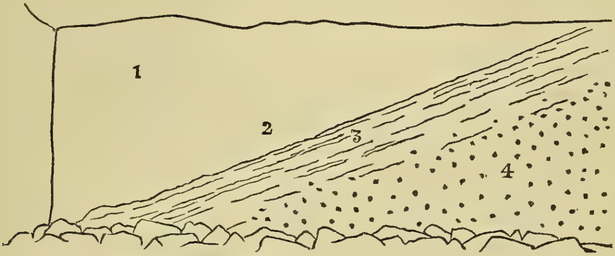
The "spilite" is quarried in more than one part of Mont de l'Ouest, a rather conspicuous eminence overlooking the sea on the north-western side of St. Heliers. The principal pit is on the south-eastern side of the hill, close to the part which is called the People's Park. It is an oblong excavation with the longer side facing roughly east. The northern side consists of a breccia, the fragments being a purplish "spilite," rarely amygdaloidal, separated by a compact green material. This rock much resembles one of the brecciated rocks which occur at Bardon Hill. At the northern end of the western side is a solid purplish "spilite," without amygdaloids. The cliff is then cut by a dyke a few feet thick, resembling a fine-grained diorite. After it comes "spilite" containing apparently many fragments, up to about 2 inches in diameter, distinguished by a pale green speckling due to abundant epidote. This rock on the whole suggested flow-brecciation. Then follows a slightly amygdaloidal "spilite." The southern wall is formed by a purplish "spilite" with rather numerous porphyritic felspars up to about $\frac{1}{4}''$ long and amygdules. Some of the latter are approximately spherical; these also seldom exceed $\frac{1}{4}''$ in diameter. Others are elongated and irregular in outline, but they are occasionally as much as an inch long.

---

[1] or "Gallows Hill," as it is named on some maps.

In the field it was hardly possible to fix the precise boundaries of the above varieties of "spilite," or to determine their dip, so that the order of succession is doubtful.

Small quarries have been opened to the north of the pit just described. In most of them little could be seen, but one, some 50 yards to northward of the last-named, gave the section as figured and showed the "spilites" to be the result of contemperaneous volcanic action.



(1) "Spilite," somewhat porphyritic.
(2) "Spilite," rather amygdaloidal.
(3) Well banded green argillite and fine grit, dipping roughly at about 45° to W.S.W. and passing down into.
(4) A breccia, the fragments being a compact purplish "spilite," sometimes amygdaloidal, rarely porphyritic, the matrix rather rotten. The breccia is exposed for about five feet vertical.

A comparison of the rocks exposed in these openings made it probable that (4) is underlain by another mass of "spilite," *i.e.* that two lava flows are parted by a breccia and a little banded gritty argillite.

Slides have been examined of three typical specimens obtained from the large quarry. In all of them the most important constituent of the compact ground mass is felspar in small crystals, generally lath-shaped, with a small extinction angle, apparently oligoclase. These microliths are separated by an aggregate material which appears in some cases to result from the alteration of the augite in a microcrystalline or micro-ophitic ground-mass. In no slide can the remains of original glass be identified with certainty, but a flow structure is not infrequently exhibited by the matrix in an orientation of the felspar microliths. In one slide some of the large broad porphyritic felspars (completely replaced) have a form rather like that of orthoclase, and in another slide a few examples resemble sanidine. But in the best preserved crystals the twinning is generally on the albite plan, the form is sometimes elongate, and the extinction often is at a low angle. Thus it seems that the majority are plagioclase. Other crystals are completely replaced, generally by viridite or chlorite, but have retained a definite form and appear to represent a ferro-magnesian silicate. Iron oxide is also present sometimes in the form of ilmenite. Amygdules, especially in one rock, are fairly large and numerous. The minerals of secondary origin in the slides include viridite, a chlorite (sometimes apparently penninite of Lévy), epidote, a carbonate (sometimes replacing felspar), azeolite, iron oxides, kaolin, and possibly augite granules.

The brecciated "spilite" from the northern side of the quarry contains angular or sub-rounded fragments with a slightly blackened or iron-stained edge. In these fragments the fresh-looking microliths of oligoclase indicate a flow structure. The intervening aggregate exhibits extremely minute crystalline specks, but, owing to the disseminated ferrite, it is difficult to decide whether this can be resolved completely into individualized minerals, or may possibly include some remains of original glass. Some of the porphyritic felspars are plagioclase; others (clearer crystals) resemble the tabular Carlsbad twins of sanidine; these sometimes form a diverging group. Rather irregular, often elongated patches of chlorite have apparently filled original vesicles microscopic in size. The matrix in which the fragments are imbedded consists of broken felspar, possibly of some quartz, and of dusty materials, probably containing minute granules of epidote or perhaps augite. This matrix, which is not very different from the ground-mass in the fragments, is somewhat banded. It is thus evident that the rock is a volcanic agglomerate.

The solid purple "spilite," from the northern end of the western face in the quarry, consists mainly of crowded felspar microliths and of interstitial material, which is either a clear viridite or a decomposed and cleaved mineral, and probably represents the pyroxene of a micro-ophitic ground-mass. Much opacite and small flakes of haematite are associated. One porphyritic crystal seems very probably to have been an augite (now largely replaced), and other more irregular patches of secondary minerals may have had a like origin. The porphyritic felspars are much decomposed. Some, however, exhibit twinning on the Carlsbad type, with which in certain cases oscillatory twinning is combined. This also occurs by itself. The usual long lath-like microliths are less frequent in the matrix of this than of other varieties, the crystallites sometimes having a rather stumpy or more irregular step-like outline.

In the amygdaloidal "spilite" from the southern face of the quarry the ground-mass was probably originally micro-crystalline; the small lath-shaped felspars are well-preserved, but the augite is replaced by granular aggregates, which sometimes occupy long prismatic spaces. Epidote is abundant in some parts, especially around the amygdules. The porphyritic felspars are large and fairly clear, but they include scattered kaolin and epidote which in some cases may result from the alteration of included magma. One crystal exhibits two arms which might belong to a Baveno grouping of a plagioclase series. The green pseudomorphs of porphyritic crystals which were probably augitic are fairly abundant. The numerous and large amygdules contain viridite, epidote (often intercrystallized with a small amount of a water-clear mineral, evidently later than the epidote and resembling quartz), calcite, or an allied carbonate. Sometimes these secondary minerals form successive zones within a vesicle; and they also occur in the ground-mass, in veins, and within porphyritic crystals.

At the base of the south face of Mont de l'Ouest, by the road to St. Aubyn, is another quarry.[1] The rock here is a compact spilite,[2] sometimes very difficult to distinguish from a flinty argillite. As it differs considerably from those already described, it may be well to add a short account of the microscopic structure.

This shows a fairly uniform ground-mass in which we cannot recognize any unaltered glass, although the chlorite and grains of iron oxide (probably in part ilmenite) which formed from the interstitial substance are very minute. The most distinct constituents are the felspar microliths which are much crowded and exhibit some approach to a fluidal arrangement. Occasional small patches where the iron oxide is in more minute and closer grains represent apparently a slight heterogeneity of the magma. With a high power the chlorite is seen to consist of very minute imperfectly rhomboidal flakes; it occurs in the ground-mass, in an occasional amygdule or crack associated with epidote, and also replacing rare microporphyritic crystals. Certain of these have the shape of augite; but two varieties may be present, since some are imperfect or skeleton forms consisting of iron oxide with viridite included. Minute well-defined crystals of a brownish mineral are possibly pyroxenic. They exhibit dichroism from brown to a very pale tint, are zoned, have a marked longitudinal cleavage, and a straight, or nearly straight, extinction.[3] The mineral may have been a hornblende, but as it occurs in short stout prisms, terminated by low-angled domes, giving transverse hexagonal sections, and contains brownish inclusions along parallel lines, hypersthene or possibly amblystegite is suggested. It is associated not infrequently with clustered granules of iron oxide or of chlorite. One crystal is long and narrow; this, however, might be a section along an edge; the dull polarization tints, and perhaps the diminished dichroism, might be the result of subsequent alteration. Except for the green pseudomorphs, which are neither large nor numerous, the rock is scarcely to be called porphyritic. It is locally cracked, indicating slight brecciation without material disturbance.

The specific gravity of the solid purple "spilite" is 2·78, that of the compact "spilite" by the athletic club building is 2·75. These results and the microscopic structures show that Prof. de Lapparent has rightly referred the rocks to the porphyrites. Probably they may be ranked with the more basic rather than with the more acid members of the group.

The "Phyllades de St. Lo" were examined at several places. So far as was seen, they are a greenish grey argillite, similar to rocks found near Granville (Normandy).[4] Two specimens obtained on the shore west of St. Aubin, not far from the boundary of the "granulite" are interesting as showing under the microscope slight contact alteration. Microscopically they are compact very hard argillites much jointed, with a flinty fracture. The more northern of the two masses exhibits the more distinct signs of bedding. Under the microscope the ground-mass appears dull, greenish, or greenish-brown, enclosing clearer generally crystal-shaped areas, which apparently indicate an incipient formation of andalusite. Very minute high-polarizing microliths of a fibrous character are scattered through the slide. Occasionally definite grains of quartz or felspar are preserved, which were doubtless constituents of the original sediment. In the southern specimen they are more numerous in one part, which therefore must have been very slightly coarser in texture. The two specimens do not exhibit any important differences, but in the more northern the incipient crystals perhaps contrast more sharply with the ground-mass. This consists of granules or quartz possibly felspar, with opacite, and abundant minute flakes of a brownish to a greenish mineral. The former variety (which dominates in the more northern outcrop) is almost certainly biotite; the latter (which characterizes the other rock) is more like a chlorite, but it may be only a hydrous form of the same mineral.

---

[1] In it at the time of our visit, in 1888, stood the building of an athletic club. —T.G.B.

[2] It is cut by two or three "greenstone" dykes.

[3] It is impossible to obtain any definite results.

[4] Many of the rocks here are greenish to purplish argillites, sometimes rather flinty, which recall certain parts of the Longmynd group.

The "chloritoschiste" of M. Noury at Petit Part was also examined.[1] He describes it as "d'une schistosité encore marquée malgré le contact des porphyres pétrosiliceux," but this structure did not appear to Professor Bonney remarkable, so far as he saw the rock. M. Noury also speaks of it as the last member of the "terrain primitif" of the globe, so a specimen was brought away for examination. In the field it had the aspect of an ancient rather basic igneous rock. Under the microscope it exhibits idiomorphic felspars much altered, some certainly plagioclase, some perhaps more nearly resembling orthoclase, with other porphyritic crystals which are very possibly pyroxenic, and are replaced by a carbonate such as ankerite or dolomite, sometimes with associated pyrite. The matrix consists of felspar much kaolinised, of viridite, of a carbonate which may have formed as a pseudomorph in felspar, and of crowded specks of pyrite. The specific gravity is 2·74. The rock is therefore a rather basic porphyrite.

V.—WOODWARDIAN MUSEUM NOTES.

By F. R. COWPER REED, B.A., F.G.S.

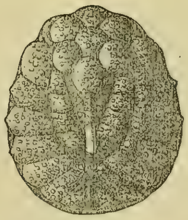
IN the Burrow Collection of fossils from the Carboniferous Limestone of the neighbourhood of Settle I have recently found a form of the genus *Cyclus* which seems to deserve notice. From a careful comparison with the figures and description of *C. Harknessi* (Woodw.) in Dr. Woodward's Monograph on Fossil Crustacea, to which we owe the greater part of our knowledge of the genus, I should consider it to be a new form allied to that species.

It may be described as follows (using Dr. Woodward's terminology): buckler oval; length 4½ lines; breadth 3¾ lines; greatest height 2¾ lines; surface granulated. In profile the buckler appears hemispherical, but the posterior end is slightly more elevated and slopes more rapidly and steeply than the anterior, in this respect agreeing with *C. Harknessi.*

---

[1] Géologie de Jersey, pp. 53, 126.

The raised "dorsal line" starts from the hinder border of the buckler and runs up the centre of the posterior surface as a narrow, somewhat indistinct ridge. Its upper extremity is much thickened and rises sharply into a pointed tubercular eminence forming the highest part of a crest elongated in an antero-posterior direction which rests upon and like a half ring encircles (at a distance of about two lines from the posterior margin of the buckler) the point of origin of the arms of a large fork-shaped ridge. This conspicuous ridge has the shape of a U: its arms diverging strongly at first and then becoming sub-parallel. The length of the fork is a little over one line and the tips of the arms are the same distance apart. The ridge has a rounded granulated surface, and appears to be homologous with the upper row of tubercles which are separated from the ribs by the upper furrow, as shown in Dr. Woodward's description and figure of *C. Harknessi*; and this U-shaped ridge may therefore probably be considered to be the result of the fusion of these tubercles. I term it here for convenience "the outer fork." Two faintly indicated ridges, arising from the anterior end of the tubercular eminence above described, run up the inside of the stout arms of this outer fork of fused tubercles: at their free extremities these faint ridges curve outwards so as to end in the inner and posterior pair of cervical lobes. This pair of faint ridges evidently corresponds to the Y-shaped "cervical ridge" described by Dr. Woodward in *C. Harknessi*, but will be termed here to avoid confusion the "inner fork."



Cyclus, sp. nov. ? (ex Woodwardian Museum) Carboniferous Limestone, Settle, Yorkshire. Magnified $\frac{3}{1}$ nat. size.

On the outer side of the arms of the large *outer fork* is a shallow groove almost as wide as the arms of this fork, and it is bordered on its outer side by a row of small tubercles which are more or less fused into a continuous ridge over the two anterior pairs of ribs, but are separate and distinct over the following four pairs; there is no tubercle visible over the last and 7th pair of ribs. In the figure of *C. Harknessi* all the tubercles are distinct. This broad *upper groove* would correspond with the upper furrow in *C. Harknessi*, but its greater width and more pronounced character are noticeable.

Below this row of small, partly-fused tubercles, and parallel to it, is a much shallower and narrower depression, from which the seven pairs of ribs arise and descend the steep sides in an oblique forward direction as rounded coarsely granulated ridges, almost as far as the lower margin, before reaching which they suddenly die out, leaving a somewhat broad granulated area, which occupies the lower edge of the buckler and is bent outwards to form an encircling rim as in *C. Harknessi.* It cannot be seen in this specimen whether the rim is continued round the anterior border or not, but presumably it is so, as shown in Dr. Woodward's restoration of the profile of *C. Harknessi* (see woodcut, Brit. Foss. Crust. p. 252).[1]

The first or most anterior rib is nearly double the breadth of the other lateral ribs, and is also more protuberant. In front of the outer fork is a group of large prominences or "lobes," which cover the anterior portion of the buckler. The innermost and central "cardiac" lobe is apparently oval in shape with a longer antero-posterior diameter, and is situated on a line joining the free extremities of the arms of the outer fork.

Lying in front and outside of this lobe is a pair of smaller lobes with polygonal borders; in them the arms of the inner fork (? = "cervical ridge" of Woodward) terminate. In front of and between them is a very slightly elevated area, which hardly merits the name of "lobe," but which undoubtedly corresponds to the anterior one in the diamond-pattern of these four lobes in *C. Harknessi.*

Around this inner group are placed five more well-defined lobes; one of these is median and anterior, the other four being paired and lateral. Along the outer margin is another row of lobes, which seem not to have been so largely developed, and are not well exposed in this specimen. They probably correspond to those in a similar position in *C. Harknessi.*

It will be seen from the above description that this specimen bears a strong general resemblance to *C. Harknessi* (Woodw.), but in some details shows differences. That these, however, are not improbably due to a different stage of development of *C. Harknessi* appears likely, (1) by the possibility of deriving the "outer fork" from a fusion of the upper row of tubercles of *C. Harknessi*; (2) because the two lateral grooves cutting the upper portions of the ribs can be derived from a broadening of the furrows described in *C. Harknessi*; (3) from the tendency to fusion of the tubercles in the row separating the two furrows in this new form.

On the other hand, it may be argued that these characters are of sufficient importance to constitute varietal or even specific modifications of *C. Harknessi.* Hence the interest of this specimen. Whether it may hereafter turn out to be a new species, a variety, or to be due only to difference of age, it will be convenient to have an easy reference to this form which is certainly distinct from any yet described, and I would therefore propose for it the name of *C. Woodwardi*, after the author who has contributed most to our knowledge of these organisms.

---

[1] See also "Contributions to British Fossil Crustacea," in Geol. Mag. 1870, Vol. VII. pp. 554–560, Pl. XXIII.

VI.—ON THE OCCURRENCE OF *URSUS FEROX* IN THE PLEISTOCENE OF MALTA.

By JOHN H. COOKE, F.G.S., etc.

THE labours of the late Admiral Spratt, R.N., and of the late Professor Leith Adams, F.R.S., in the cavern deposits of the Maltese Islands were rewarded by the finding of a unique and interesting land fauna, among which were Elephants, Hippopotami, Land-tortoises, gigantic Dormice, and aquatic Birds, the presence of which in so limited an area was incompatible with the present existing physical conditions of the Islands. While carrying on his work of investigation in a cave in the Zebbug Gorge, Uied el Kbir, in 1859, Spratt noticed that many of the remains of Elephants that were exhumed presented the appearance of having been fiercely gnawed,[1] and later on when Adams was excavating the Mnaidra gap it was observed that many of the elephantine remains were in a similar condition.

From the situations in which the remains were found, and their condition, these gentlemen inferred that carnivora had lived in the district contemporaneously with the hippopotami; but notwithstanding the most diligent research extending over a period of twenty years, the only tangible evidences in support of their inferences were these gnawed bones.[2]

During the Spring of the present year I was engaged in carrying out, with the aid of a grant from the Royal Society, some excavations in the Har Dalam cavern, a subterraneous gallery situated in a gorge of the same name in the eastern extremity of Malta, and after having excavated six large trenches and obtained some hundreds of bones of *Hippopotamus pentlandi*, *Elephas mnaidriensis*, *Cervus barbarus*, and numerous other animals, I had the satisfaction of discovering an entire ramus of the lower jaw of a Bear, with its canine and molars *in situ*, as well as five other canines belonging to other individuals of the same species.

The trench in which the jaw and teeth were found is situated on the left-hand side of the cavern, at a distance of fifty feet from the entrance. The floor was strewn to a considerable depth with large boulders, which in some places were heaped up against the sides of the cavern to a height of from two to three feet. Having cleared a space of about thirty square yards, I commenced operations on a friable marly loam, which in this part of the cavern takes the place, as the surface layer, of the red soil that is found farther within.

The first evidence of the presence of the carnivoræ was a large canine, the fang of which was unfortunately broken by a blow from the pick of one of the workmen, before the tooth was noticed. This discovery was soon followed by that of a complete ramus of the lower jaw, with its molars, and canine teeth *in situ*. The peculiar nature of the matrix in which it was embedded unfortunately prevented me from getting it out entire. The articular processes broke off, but a few fragments were recovered and pieced together.

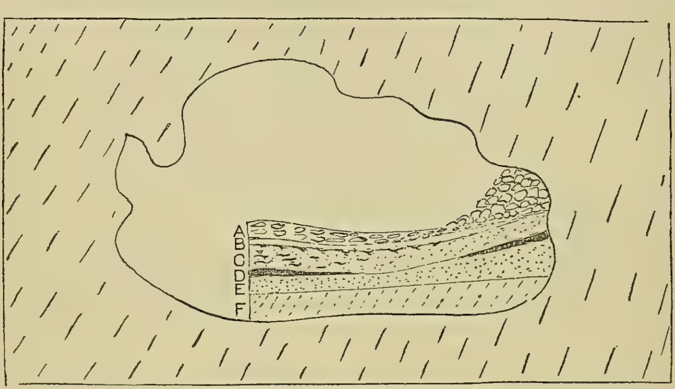
---

[1] Proc. Geol. Soc. vol. xxiii. p. 288.

[2] In a collection of fossils sent by Capt. Spratt to Dr. Falconer, a small canine of a carnivorous animal of the size of a fox was present.

Four other canines were afterwards discovered, each of which was in a fairly perfect state of preservation.[1] Associated with these remains were found several vertebræ and fragments of limb-bones of hippopotamus, and vertebræ and portions of horns of stags; but none of them presented any evidences of having been gnawed.

The excavation which, when finished, measured 12 feet, by 10 feet, by 6 feet, exhibited in section the following sequence of deposits:



Section of Har Dalam Cave, at Trench No. VI., showing Succession of Deposits.

A. A layer of rounded boulders that lay scattered over the floor to a depth of two feet.
B. Cave-floor consisting of a friable marly loam, about nine inches thick, containing numerous land-shells, roots of plants, limpet shells, a shell of a *Cerithium*, and the vertebræ of a small fish. These latter had evidently been introduced.
C. A stratified layer of rounded boulders, intermixed with a grey marly loam containing an abundance of land-shells.
D. A friable marly loam with a few pebbles. Entire antlers, jaws, and limb-bones of *Cervus barbarus*, together with fragments of very old pottery, occurred in abundance.
E. A layer of indurated, light-grey loam containing a few antlers, teeth, and bones of *C. barbarus*, and a jaw and five canines of *Ursus ferox*, and remains of *H. pentlandi*.
F. A layer of about 1 foot 6 inches in thickness, similar in composition to E, but more indurated. Lying at the base of this layer, and on the original rock-floor of the cave, were numerous molars, portions of tusks, and limb-bones of Hippopotamus.

All of the layers in this section presented distinct evidences of stratification; but in the lower ones the thickness of the deposits and their comparative homogeneity contrast strongly with the numerous thin layers of which the upper beds are composed, and with the assortment of boulders, pebbles, and organic remains of which they are made up.

From the evidences thus afforded its seems that the deposits owe their origin to periodical floodings of the cavern, during which the remains that lay scattered over the cavern floor, near the mouth, were washed further within and were buried in the muddy sediments of the water.

---

[1] One of these Mr. A. S. Woodward, F.G.S., has determined as belonging to the left side of the mandible of a species of *Canis*, equalling a wolf in size.

The state of mineralization in which the remains of the Hippopotamus, the Stag, and the Bear are, indicates that these animals occupied the Maltese area contemporaneously.

Further researches will, I have no doubt, lead to other discoveries, and it will therefore suffice for the present to simply place on record these, the first tangible evidences of the former occurrence of carnivora in the Maltese area.

NOTICES OF MEMOIRS.

Dr. C. I. FORSYTH-MAJOR—ON THE FOSSIL-REMAINS FROM SAMOS.

C. I. FORSYTH MAJOR, LE GISEMENT OSSIFÈRE DE MITYLINI. EXTRAIT DE SAMOS, ETUDE GÉOLOGIQUE, PALÉONTOLOGIQUE ET BOTANIQUE. Par C. DE STEFANI, C. I. FORSYTH MAJOR, et W. BARBEY. (Lausanne, Bridel, 1892.)

SEVERAL ancient authors, as Ælianus, Heraclides, Ponticus, and others, speak of the former existence of monsters on the Isle of Samos, and mention expressly that their bones—which are claimed by Plutarch to be the remains of the Amazons slain by Bacchus—are still to be seen in the island.

This induced the author, when visiting Samos for other scientific purposes, to search for fossil bones; and he was fortunate enough to find a rich deposit of them in the vicinity of the village of Mitylini, in the eastern part of the island, imbedded in a volcanic tufa, alternating with strata of sandy marls and gravels. These same deposits had been seen and described almost fifty years ago by Admiral (then Lieutenant) Spratt, who failed, however, to discover fossils in them. The following is a complete list of the Vertebrate fauna of Samos, compared with other deposits in which a certain number of species have been found agreeing with those of Samos.

From the following comparison it may be seen, that of the 43 Mammalian species from Samos, 25 at least are represented equally at Pikermi (Greece), 13 at Maragha (Persia), 7 at Baltavar (Hungary), 7 at Mont Leberon (France), so that the contemporaneity of all these deposits, and many others less well known, is placed beyond doubt.

Whilst the majority of Palæontologists assign all these deposits to the older Pliocene, the author adduces reasons for which, in accordance with the views of Professors Boyd Dawkins, Depéret, Gaudry, and others, he holds them to be Upper Miocene. He points out that the other view is to be traced back to Dr. Theodor Fuchs, who regarded a very recent deposit of fossil shells near the sea-shore at Raphina, four miles distant from Pikermi, as contemporaneous with the Pikermi beds. If this view were correct, the Pikermi beds would have to be assigned to the uppermost Pliocene, or even to the Pleistocene, so that Dr. Theodor Fuchs must have been led into an error of observation.

List of Animal Remains from Samos showing their Occurrence also in other Localities.

	Samos.	Concud. (Spain.)	Mt. Leberon. (France.)	Croix-Rousse. (France.)	Baltavar. (Hungary.)	Pikermi. (Greece.)	Troy. (Asia Minor.)	Maragha. (Persia.)
MAMMALIA.								
Primates.								
Fam. Cercopithecidae.								
Mesopithecus Pentelici, Wagn.	?	...	...	...	x	x	...	...
Carnivora.								
Fam. Felidae.								
Machairodus, sp.	x	...	...	...	...	...	...	...
Felis Neas, Major	x	...	...	...	...	...	...	...
Fam. Hyaenidae.								
Lycyaena Chaeretis, Hens. (Gaudr. et Lart. sp.)	x	...	...	...	...	x	...	...
Hyaena eximia, Roth et Wagn.	x	x	x	...	x	x	...	x
Fam. Viverridae.								
Ictitherium Orbignyi, Gaudr.	x	...	x	...	...	x	...	...
——— *robustum*, Gaudr. (Nordm. sp.)...	x	...	...	...	...	x	...	...
——— *hipparionum*, Gaudr. (Gerv. sp.)	x	...	x	...	...	x	...	x
Fam. Mustelidae.								
Mustela palaeattica, Weith.	x	...	...	...	...	x	...	...
Promephitis Larteti, Gaudr.	x	...	...	...	...	x	...	...
Meles maraghanus, Kittl.	x	...	...	...	...	...	...	x
Artiodactyla.								
Fam. Antilopidae.								
Palaeoryx Pallasii, Gaudr. (Wagn. sp.)	x	...	...	...	...	x	...	x
——— *rotundicornis*, Maj.	x	...	...	...	...	x	...	...
Protoryx Carolinae, Maj.	x	...	...	...	...	x	...	...
——— *longiceps*, Maj.	x	...	...	...	...	...	...	x
——— *Gaudryi*, Maj.	x	...	...	...	...	...	...	x
——— *Hippolyte*, Maj.	x	...	...	...	...	...	...	...
Helicophora rotundicornis, Weith.... ...	x	...	...	...	...	x	...	x
Gazella deperdita, Gaudr. (Gerv. sp.) ...	x	x	x	x	x	x	...	x
Gazella, sp.	x	...	...	...	...	...	...	...
Gazella ?	x	...	...	...	...	...	...	...
Prostrepsiceros Woodwardii, Maj. ...	x	...	..	...	...	...	...	...
Prostrepsiceros (?) sp.	x	...	...	...	...	...	...	x
Palaeoreas Lindermayeri, Gaudr. (Wagn. sp.)...	x	...	x	...	...	x	...	x
Tragoceros Valenciennesi, Gaudr.	x	...	...	...	...	x	...	...
——— *amalthaeus*, Gaudr. (Roth et Wagn. sp.)	x	x	x	x	x	x	x	?
Fam. Ovidae (?).								
Criotherium argalioides, Maj.	x	...	...	...	...	...	...	...
Capra ?	x	...	...	...	...	...	...	...
Fam. Giraffidae.								
Samotherium Boissieri, Maj....	x	...	...	...	...	...	...	x
Palaeotragus Roueni, Gaudr.	x	...	...	...	...	x	...	?
Helladotherium Duvernoyi, Gaudr. ...	?	...	...	...	...	x	...	...
Fam. Cervidae.								
Dremotherium (?) *Pentelici*, Gaudr. ...	x	...	...	...	...	x	...	...
Fam. Suidae.								
Sus erymanthius, Roth et Wagn.... ...	x	...	...	...	x	x	x	x
Perissodactyla.								
Fam. Equidae.								
Hipparion mediterraneum, Hens.	x	x	x	x	x	x	x	x
——— *minus*, Pavlow	?	...	...	...	...	...	...	...

	Samos.	Concud. (Spain.)	Mt. Leberon. (France.)	Croix-Rousse. (France.)	Baltavar. (Hungary.)	Pikermi. (Greece.)	Troy. (Asia Minor.)	Maragha. (Persia.)
Fam. Rhinocerotidae.								
Rhinoceros pachygnathus, Wagn.... ...	x	...	...	...	x	x	...	...
——— *Schleiermacheri*, Kaup.	?	...	...	x	...	x	...	...
Proboscidea.								
Fam. Elephantidae.								
Mastodon Pentelici, Gaudr. et Lart. ...	x	...	...	...	x	x	...	x
——— *turicensis*, Schinz.	x	...	...	...	...	x	...	...
Fam. Dinotheriidae.								
Dinotherium, sp.	x	...	...	...	...	...	...	...
Ancylopoda.								
Fam. Chalicotheriidae.								
Chalicotherium Pentelici, Gaudr. sp. ...	x	...	...	...	...	x	...	...
Rodentia.								
Fam. Muridae.								
Acanthomys Gaudryi, Dames	x	...	...	...	...	x	...	...
Chiroptera.								
Fam. ?								
Incomplete cranium of indetermined genus.	x	...	...	...	...	...	...	...
Edentata.								
Fam. Orycteropodidae.								
Orycteropus Gaudryi, Maj.	x	...	...	...	...	...	...	...
REPTILIA.								
Testudinata.								
Fam. Chersidae.								
Testudo, sp.	x	...	...	...	...	...	...	...
AVES.								
Ratitae.								
Struthio Caratheodoris, Major.	x	...	...	...	...	...	...	...
Carinatae.								
Fam. Ciconiidae.								
Amphipelargus Majori, Lyd.	x	...	...	...	...	...	...	...
Avis	x	...	...	...	...	...	...	...

The almost universal view that the fauna of the Upper Siwaliks is the eastern continuance of the Pikermi fauna, must likewise be abandoned. The two have not one species in common. The former is doubtless more recent than the latter, in which the number of still living genera is much less. In the fauna of Pikermi and Samos there are wanting such living genera as *Anthropopithecus*, *Macacus*, *Semnopithecus*; *Canis*, *Ursus*, *Mellivora*, *Lutra*; *Elephas*; *Equus*; *Hippopotamus*; *Camelus*, *Tragulus*; *Rhizomys*, *Lepus*. characteristic of the Siwaliks on the one hand, and partly of the Upper Pliocene of Europe on the other. Neither can any of the Antelopes of Pikermi and Samos, although showing relations to living African forms, be identified with living genera (with the single exception perhaps of *Gazella brevirostris*, Gaud.), whilst among the Siwalik Antelopes we find no less than five living genera at least, viz. *Boselaphus*, *Hippotragus*, *Gazella*, *Tetraceros*, *Alcelaphus*.

Short characteristics are given of several particularly interesting members of the Samos fauna. The author adduces reasons for considering *Chalicotherium* (*Ancylotherium*) to be neither an Edentate nor a Perissodactyle, but forming a separate order.

Amongst the Ruminantia chiefly worthy of mention is a member of the Giraffidae, the *Samotherium Boissieri*, a complete skull of which has recently been added to the British Museum. The male possessed horn-cores implanted directly on the roof of the orbits; the females were hornless. A near relative of the *Samotherium* was the *Palæotragus Roueni* (Pikermi, Samos), which hitherto has been considered as an Antelope.

The *Criotherium argalioides*, chiefly represented by four nearly complete crania in the British Museum, is a most curious form of Ruminant, showing some affinities to the Antelopidæ and Ovidæ, though it cannot be assigned to either of these families. In the form of the horn-cores it resembles the *Budorcas* of Assam and Thibet.

The new genera *Protoryx* and *Prostrepsiceros* are considered to be the forerunners respectively of *Hippotragus* and *Strepsiceros*, both living African Antelopes.

A species of *Orycteropus*, the first true Edentate found fossil in the Old World, has been already recorded in this MAGAZINE on a former occasion (See GEOL. MAG. Dec. III. Vol. VI. 1889, p. 431).

Amongst the scanty Avian remains deserves mention a *Struthio*, represented by a femur and part of the pelvis, scarcely to be distinguished from the African Ostrich.

The principal collection of the Samos fossils has been presented by its owner, Mr. William Barbey, to the College Gaillard at Lausanne. A second collection, important chiefly for its complete specimens of Ruminants, is actually in the British Museum. Smaller collections of duplicates have been presented to the museums of Geneva, Lausanne, and the Pythagoras Gymnasium at Vathy (Samos). Lastly a smaller collection brought from Samos by Dr. G. von Bukowski, of the Geologische Reichsanstalt of Vienna, is deposited in the Geological and Palæontological Museums of the Vienna University.

REVIEWS.

I.—THE FOSSIL FISHES OF THE BRITISH COAL MEASURES.

"ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS. Part I. PLEURACANTHIDÆ." By JAMES W. DAVIS, F.G.S., F.L.S. Sci. Trans. Roy. Dublin Soc. [2] vol. iv. pp. 703–748, pls. lxv.–lxxiii. 1892.

THE British Coal Measures have probably yielded more remains of fishes than the corresponding horizon in any other country, and the collections of these fossils are now very extensive. At the time when Agassiz was preparing his "Poissons Fossiles," they were almost the only Upper Carboniferous fish-remains accessible to him, and they thus comprise many of the types of his species; but since those early researches, most of the publications on the subject have been brief, scattered, and desultory, and our knowledge of the fishes of the British Coal Measures has in some respects—though not in all—lagged behind that of certain corresponding foreign strata. About fifteen years ago the Palæontographical Society published the first part of two memoirs proposing to include a large portion of the subject; but nothing further has been heard of these, and there seems to be no immediate prospect of their continuation. It is, therefore, with considerable satisfaction we are able to announce, that the Royal Dublin Society has decided to publish a series of descriptions and figures of all the more important fish-remains from the British Coal Measures that are available for the purpose. The work has been undertaken by Mr. James W. Davis, who, by his monograph of 1883, has already given a definite meaning to the long series of manuscript names applied by Agassiz to the fragmentary ichthyolites from the Lower Carboniferous, and who has himself made many contributions to our knowledge of the fish-fauna of the Carboniferous Period. The memoir will appear in annual instalments, and the first part has now reached us.

This opening part deals with the Elasmobranch family of Pleuracanthidæ, of which numerous fragmentary remains occur in all Coalfields, and of which so many tolerably complete skeletons have been discovered in Germany, Bohemia, and France. Hitherto, the British material has not been examined in detail with reference to these discoveries on the European Continent, or in comparison with certain discoveries of Pleuracanth skulls in Texas; and Mr. Davis' survey is thus in great part new, especially as regards the associated groups of teeth and remains of the endoskeletal cartilage. Nine beautiful plates, by Mr. Crowther, serve to illustrate the text, and will form a contribution to the subject of permanent value, however much future discoveries of skeletons may cause modifications in the taxonomy and interpretations adopted. One can only regret that the known British fossils should as yet remain comparatively fragmentary.

The Pleuracanthidæ are placed by Mr. Davis in the order Ichthyotomi, and the genus *Pleuracanthus* is retained in the wide sense in which he and Egerton proposed to regard it years ago. It is pointed out still more clearly than before that there exists every possible gradation between the spines named *Pleuracanthus* and those named *Orthacanthus*; and one specimen is described (p. 720, pl. lxvi.) in which it is proved that there occur in a single mouth teeth of all the three forms determined by Fritsch as characteristic of *Pleuracanthus*, *Orthacanthus*, and *Xenacanthus* respectively. It is also shown that teeth with round cusps, and others with compressed keeled cusps, occur in one and the same jaw, thus confirming an observation already made by Koken in the Permian Pleuracanths of Germany. The teeth, indeed, prove to be of little or no value for the diagnosis of species; and for the systematic arrangement of the fossils Mr. Davis relies upon the characters of the spines.

One fossil from the Yorkshire Coal Measures is interpreted as a pectoral fin, and a few neural or hæmal arches and fin-supports are referred to; but the only skeletal elements of importance are portions of cartilage. There are some beautiful figures of the more or less fragmentary jaws; and many other pieces of calcified cartilage of varying shape are both described and figured. Mr. Davis's main contention is, that many of the cartilages show a distinct segmentation—a feature observed by Cope in the Pleuracanth skulls from Texas; and certainly, it must be admitted, some of the fossils present appearances rather suggestive in this connection. More satisfactory specimens, however, are still required before any definite result can be arrived at; and whether or not Mr. Dinning's fossil, for example (pl. lxvii. fig. 2), be the cranial roof of a Pleuracanth, the restored sketch (*ibid.* fig. 2*a.*) appears to us to be unjustifiable imagination totally at variance with the most fundamental principles of Elasmobranch anatomy. We are disposed to criticise, too, when clavicular elements are ascribed to the shoulder-girdle (p. 711); and there is a distinct contradiction in regard to shagreen, this being said to be absent in *Pleuracanthus* on p. 705, while "masses of shagreen" are described as found with remains of this genus on p. 714. Some of the species must have attained a very large size, one slab of jaws from Newsham probably indicating a fish between 3 and 4 metres in length.

The systematic portion of the work, as we have said, relates chiefly to spines, and the following species are recognized:—

Pleuracanthus lævissimus, Ag.
——— *robustus*, Davis.
——— *Wardi*, Davis.
——— *undulatus*, sp. nov.
——— *tenuis*, Davis.
——— *denticulatus*, Davis.
——— *Howsei*, sp. nov.
——— *alatus*, Davis.
——— *erectus*, Davis.
——— *horridulus*, Traquair.
——— *cylindricus* (Ag.) Davis.
——— *Thomsoni*, sp. nov.
Pleuracanthus obtusus, nom. nov.
(=*Phricacanthus biserialis*, Davis).
——— *serratus*, sp. nov.
——— *Woodwardi*, sp. nov.
——— (*Lophacanthus*) *Taylori*, Stock.
——— (*Compsacanthus*) *triangularis*, Davis.
——— (*Diplodus*) *equilateralis*, Ward. [A tooth.]
Anodontacanthus acutus, Davis.
——— *obtusus*, Davis.

All these spines are described in detail, with their ascertained distribution, and each description is accompanied by one or more fine figures. The specific characters are chiefly found in the shape of the transverse section, and in the form and situation of the denticles. Only a very small amount of variation is allowed in each case, while several new forms of spine are named; and it must remain for future discoveries of complete fishes to determine how far these observed differences are of specific value. We would only remark that it is somewhat hazardous to identify two Lower Carboniferous spines (as the author does) with species characteristic of the Upper Carboniferous; and we are inclined to think that some of the differences in denticulation will prove to be due entirely to chemical erosion during fossilisation.

The fragmentary nature of the fossils described admits of so much difference of opinion in many determinations, that it scarcely seems profitable without further evidence to discuss the various points.

Mr. Davis has done good service in amassing the series of facts, which will remain long after the personal equation has vanished in fuller knowledge; and we feel that at last there is a prospect of the British Upper Carboniferous fishes being speedily described and figured as they deserve to be. A. S. W.

II.—CATALOGUE ILLUSTRÉ DES COQUILLES FOSSILES DE L'ÉOCÈNE DES ENVIRONS DE PARIS. Par M. COSSMANN. Annales de la Société Royale Malacologique de Belgique. Bruxelles, 1886—1892.

THE appearance of the fifth and last fascicule of M. Cossmann's important "Catalogue" affords a convenient opportunity of reviewing the whole work. Fasciculi I. and II. are devoted to the Pelecypoda; III. and IV. to the Scaphopoda and Gasteropoda; and V. to the Pteropoda, Cephalopoda, Brachiopoda and a general supplement. The work is much more than a mere enumeration of the mollusca occurring in the Eocene beds of the Paris Basin; it contains diagnoses of the majority of the genera and species, the range in time of the latter, and new localities; whilst a large number of new genera and species are described. Each fascicule is accompanied by a number of carefully executed plates.

M. Cossmann's "Catalogue" really supplements the well-known works of M. Deshayes, and brings the whole up to date. The extent of the revision necessary to accomplish this, the critical knowledge possessed by the author in regard to living mollusca, and to bibliography, and the infinite pains he must have bestowed upon the work, cannot be fully appreciated except by those who institute careful comparisons between the old work and the new. It is not too much to say that the originality of the "Catalogue," and the systematic and convenient manner in which the author has marshalled his facts, places his work in the front rank of malacological literature. It will always form a useful book of reference to students of Tertiary mollusca. In many respects it has modified the classification of genera, and species of doubtful affinity have found convenient resting-places. Some genera which have hitherto comprised the most miscellaneous assemblage of species, have been shorn of all save those having some legitimate affinity with the generic type. These changes, together with those brought about in enforcing the rules of nomenclature, have clothed certain of the commoner forms of Eocene mollusca with strange designations. The changing of names is always to be regretted, but if consistence and uniformity in nomenclature are ever to be attained the alteration in most instances is imperative; but in the case of the Catalogue before us the alterations of generic denominations, frequent as they are, are due to the careful zoological revision to which the species have been subjected, rather than to mere caprice on the author's part, in his interpretation of the so-called "laws of nomenclature."

In view of the opinions held by an influential section of continental malacologists, we can hardly blame the author for adopting "pre-Linnean" names, though from an English standpoint this proceeding is a reprehensible one; it is satisfactory, however, to note that the changes due to this are exceedingly few and comparatively unimportant in the work under review. The greater number of genera have been divided into sections, or sub-genera. The value of such a classification is very manifest to workers in those groups containing large numbers of species, and is certainly a more convenient method than by elevating the sub-genera into genera, whereby the original generic name is not infrequently lost sight of.

In fascicule I. we note that a new genus *Fabagella* is proposed for the original *Corbula faba* of Deshayes, who in his "Supplement" had referred it to the genus *Poromya*, which M. Cossmann states is not found in the Paris Basin. He elevates *Arcopagia*, which is considered by many authors to be merely a sub-genus of *Tellina*, into a genus, principally because of the special characters exhibited by the sinus and general shape of the shell. *Venus conformis*, Desh., forms the type of the new genus *Atopodonta*, being separated from *Venus* properly so-called, on account of the particular disposition of the hinge, and absence of a sinus. Following other authors, M. Cossmann substitutes the name *Meretrix* for *Cytherea* by reason of the priority of the former; similarly, *Sphærium* takes the place of *Cyclas*; and *Trapezium* that of *Cypricardia*. Of all the species of *Cardium* found in the Paris Basin, only one, *Cardium Bazini*, is referred to the typical form of the genus.

Fascicule II. continues the description of the Pelecypoda. We notice that *Fimbria* is replaced by *Corbis*, the former designation having been used by Bohadsch in 1761 for a nudibranch, but as the date mentioned is prior to the appearance of the 12th edition of the "Systema Naturæ," we should prefer to retain *Fimbria* of Mégerle, and cite *Corbis* in the synonymy. *Cyclas*, Klein, 1753 (Stoliczka, 1870), is retained by M. Cossmann as a section of *Lucina*, but, as we have seen, the name *Cyclas*, Brug. 1792 (used for a very different Pelecypod) falls in synonymy under *Sphærium*; the genus having been used by Bruguière and others. Stoliczka was not justified, from our point of view, in bringing on the *Cyclas* of Klein, and we are disposed to adopt *Divaricella*, proposed by von Martens in 1880 for this genus. The resuscitation of pre-Linnean authors' works also leads our author to displace the well-known *Lima*, Brug., by *Radula*, Rhumphius, 1711; Klein, 1753. J. Sowerby's *Axinus*, 1821, is adopted, but the name having been used by Kirby in 1817 it cannot be retained, and moreover is synonymous with *Thyasira*, Leach (*fide*, Lam. 1818); in case the last-mentioned should be considered as identical with *Thyatira*, Hübner, 1816 (as by M. Cossmann), *Axinus* should apparently be replaced by *Cryptodon*, Turton, 1822, or by (?) *Ptychina*, Phil., 1836. Our author does not accept Monterosato's genus *Neolepton*, 1884, but includes it in *Lepton*; he does not agree that the oblique shells striated concentrically, on which the former genus was founded, can be generically differentiated from *Lepton*. The diagnosis of *Erycina* is amended in accordance with the typical species; this had been rendered necessary on the removal of certain forms which were shown not to belong to the genus.

The diagnosis now established is based upon *E. pellucida* and its allies; in thus limiting the characters of the genus, it becomes evident that *Erycina* does not exist in modern seas; the so-called *E. Geoffroyi,* living in the Mediterranean, is in reality a *Kellyia.* *Venericardia* is regarded as a section of *Cardita,* but it is impossible in the present state of our knowledge to distinguish one from the other; the hinge in both varies by the inclination of the teeth, following the elongation of the shell, and we have yet to learn that this was accompanied by any material modification in the structure of the animal. The author agrees with the alteration of *Pectunculus* into *Axinœa*; but for some unexplained reason the former name is retained in his subsequent work, "Révision sommaire de la faune du Terrain Oligocene Marin aux Environs d'Étampes," 1891, p. 40. By the adoption of Fischer's views in regard to *Pecten,* that genus is said not to occur in the Paris Basin, the majority of the species hitherto included therein being now termed *Chlamys.*

Fascicule III. devoted to the Scaphopoda, and the non-pulmonate holostome Gasteropoda is prefaced by a few remarks on the classification and method of description adopted in the work. The author, like his *confrères,* in illustrating the Gasteropoda, prefers to draw them upside down (*i.e.* with the mouth directed upwards and apex downwards), as he believes this position places the more interesting phenomena, from a generic point of view, in clearer light. In regard to the description of the ornamentation of the whorls of the shell, he truly remarks that the terms "transverse" and "longitudinal" are often misapplied and mistaken one for the other; he therefore proposes to use the term "axial" for all ornamentation parallel (or nearly so) to the direction of the axis, *i.e.* that usually formed along the lines of growth of the shell; and the word "spiral" for all ornament parallel to the line of superposition of the whorls of the spire. Special reservations are, of course, made for such genera as *Patella, Fissurella,* and *Hipponyx.*

The interesting genus *Pleurotomaria* is represented in the Paris Basin by one species, *P. concava,* Desh., but it is rare. The name *Calliomphalus* is proposed for those species having close affinity with the so-called *Turbo squamulosus* of Lamarck. The classification adopted for the Trochidæ is similar to that of Dr. Fischer; and Watson's genus *Basilissa* is represented by five species. The Scalidæ are arranged mainly on the lines proposed by M. de Boury, but the non-publication by that authority on this family, of figures illustrating several of his MSS. species, has led M. Cossmann to supply the want, and to give a particularly useful illustrated account of the whole. He proposes a new genus, *Canaliscala,* which is characterized by the possession of a short canal, and of which *Scalaria heteromorpha* of Deshayes is the type. The author does not replace *Paludina* by *Vivipara,* though he cites the latter in synonymy.

Fascicule IV. is devoted to the siphonostome and pulmonate Gasteropoda, and there can be no question that the author's study of this section—especially the first division—has been very thorough. The Cerithidæ of the Paris Basin were in a state of chaos before the publication of M. Cossmann's "Catalogue"; in round numbers 250 species occur which had to be worked out and placed in their proper genera in this family, and it was found desirable to propose several new genera and sub-genera in accomplishing the work. The author must have considerable courage in attempting to distinguish *Potamides* from *Cerithium* in the fossil state, and the division is necessarily an arbitrary one. In regard to *Lovenella*, Sars, 1878, the author remarks that Monterosato has said that the name is pre-occupied, but this is disregarded on the grounds that the latter did not give either author or date of pre-occupation. We may therefore recall the fact that Hincks, in 1868, had used the term *Lovenella* for a Cœlenterate (Hist. British Hyd. Zoophytes, 1868, vol. i. p. 177), as Mr. R. B. Newton has pointed out. The last-mentioned author replaces the molluscan genus *Lovenella* by *Cerithiella*, Verrill, 1882, which M. Cossmann considers, from etymological grounds, is pre-occupied by *Ceritella*, Morris and Lycett, which term, however, we think is sufficiently distinctive. In consequence of our author adopting pre-Linnean works, the well-known *Rostellaria*, Lam., 1799, is replaced by *Gladius*, Klein, 1753. Amongst the Fasciolariidæ we find a new genus, *Streptochetus*, proposed for several species having considerable affinities with *Latirus*; M. Bayle, in classifying the collection in the École des Mines, Paris, believed that these peculiar forms should be included in a new genus, *Kelletia*, of which *Fusus Kelleti*, Forbes, is the type, and which Dr. Fischer considers is a sub-genus of *Siphonalia*. M. Cossmann, however, shows that the Paris Tertiary species differ from the type of *Kelletia*, and they cannot be included under *Siphonalia* on account, amongst other things, of the characters of their embryo, by the length and twisting of their canal, and by their columella, which is sometimes plicated. In spite of the exhaustive work of M. Jousseaume on *Cancellaria*, our author is able to add two new sub-genera thereto. The Conidæ have been the subject of considerable revision, and M. Cossmann's original work amongst *Pleurotoma* might fittingly be paralleled with that of Bellardi on the same genus. The Order Nucleobranchiata is represented in the Paris area by one species only—the ancient *Cyclostoma spiruloides* of Lamarck, which forms the type of a new genus *Eoatlanta*. Amongst the Pulmonata may be mentioned the new genus *Acroria*, which is placed doubtfully in the Gadiniidæ, and four new subdivisions, two of which are sections of the already overburdened *Helix*.

Fascicule V. shows that only two genera of Pteropoda are present in the Paris Basin Eocene—*Spirialis* and *Valvatina*. The *Vaginella Parisiensis* of Watelet, said to have come from the Sables de Cuise, at Mercin, is eliminated, as M. Cossmann believes that it is really a *V. depressa* from the Bordeaux district, with which we entirely concur. *Euchilotheca succincta*, Defrance, is mentioned by some as a Pteropod, but our author has placed it amongst the Cæcidæ. The Cephalopoda are represented by the genera *Sepia*, *Belosepia*, *Beloptera*, *Nautilus*, and *Aturia*; whilst five genera of Brachiopoda occur, viz.: *Crania*, *Terebratulina*, *Terebratula*, *Kingena*, and *Cistella*.

In the Supplement, which is a lengthy one, the author describes several new species, and adds some new localities. The Catalogue was such a long time passing through the Press that many alterations in nomenclature were in the meanwhile proposed. A large number of these were made by Messrs. Harris and Burrows in their work on the "Eocene and Oligocene Beds of the Paris Basin" (Geol. Assoc. separate publication) 1891; and by Mr. R. B. Newton in his "Systematic List of the F. E. Edwards' Collection," etc. (British Museum, Nat. Hist.) 1891, and are duly acknowledged by the author of the work under review.

The following abridged Table may be useful as giving some idea of the number and distribution of the species found in the Paris Basin Eocene :—

	Number of Species Catalogued.	Stratigraphical Distribution.				Paris Basin. Species occurring in	
		Lowest Eocene.	Lower Eocene.	Mid. Eocene.	Upper Eocene.	Belgium.	England.
Pelecypoda.	1075	161	295	529	388	136	144
Gasteropoda.	2080	291	487	1104	737	96	207
Pteropoda.	4	—	1	3	—	—	—
Cephalopoda.	14	1	5	10	2	6	7
Brachiopoda.	20	1	—	18	1	2	—
Totals.	3193	454	788	1664	1128	240	358

Upper Eocene includes the "Sables Moyens," and the Saint-Ouen limestone.

Middle Eocene refers to the three horizons of the Calcaire Grossier.

Lower Eocene applies to the sands of Aizy and Cuise.

Lowest Eocene comprises the "Sables de Bracheux," Rilly limestone and Lignites.

The number of species said to be common to the Paris and English beds will doubtless be materially augmented when the mollusca from the latter have been more fully described.

The "Supplement" concludes with an exhaustive index of genera, sections and species.

Reviewing the whole work, we think that the author has had a tendency to create rather too many sections in certain genera. We have heard influential French palæontologists make disparaging remarks anent the large number of species described by Bellardi, many of which are so closely allied as to be frequently indistinguishable from each other; in other words, they accused the lamented Italian malacologist of being a "hair-splitter." So far as *Nassa*, and a few other genera are concerned, we entirely agree with them, and the method at present being resorted to by Bellardi's successor, of making innumerable "vars.," is certainly to be deplored. But those "who live in glass houses should not throw stones," and our French contemporaries would do well to revise the large number of so-called species included in the Naticidæ, Cerithidæ, and Turritellidæ of the

Paris Basin in such a manner that with the type specimens, or good figures and descriptions before us, we should stand a reasonable chance of correctly determining a species.

The Royal Malacological Society of Belgium is to be congratulated on publishing such an extensive and important work; it will not be out of place, however, to mention that the author has been put to considerable expense in the matter, and the "Catalogue" is now sold in separate form.

The value of M. Cossmann's book lies in the critical manner in which he has dealt with the more or less fragmentary work of his predecessors, and in the careful and erudite manner in which he has modernized his subject. That some alterations will become necessary in overhauling new material is only to be expected, and new species will, in course of time, be added to the fauna, whilst the systematic positions of certain genera and species are yet capable of revision. As the author truly says, "L'histoire paléontologique d'une région est, en effet, comme un livre toujours ouvert, sur les pages duquel on ne peut jamais inscrire le mot *fin*." G. F. H.

III.—A MONOGRAPH OF THE CARBONIFEROUS AND PERMO-CARBONIFEROUS INVERTEBRATA OF NEW SOUTH WALES. Part II. ECHINODERMATA, ANNELIDA AND CRUSTACEA. By R. ETHERIDGE, junior. Mem. Geol. Survey New South Wales, Palæontology No. 5. Sydney, 1892. 4to. pp. i.–ix. and 65–132. Plates xii.–xxii.

THE earlier finds in the Carboniferous rocks of Australia appeared to show the existence of a fauna very different from that co-existing in Europe. De Koninck, in his "Récherches sur les fossiles paléoziques de la Nouvelle Galles du Sud," combated that view, and went a little too far in assuming specific identity between Australian forms and similar ones either in Europe or North America. The general facies is indeed much the same, but the more accurate researches now being carried out by the accomplished author of the work before us show a parallelism rather than an identity of development. One fact, however, on which De Koninck laid stress, is still prominent, and that is the large size of many of these Australian forms as compared with that of their allies in other parts of the world: the star-fish and sea-urchins, now first made known to us from Australia, are indeed prize specimens; among the crinoids, the genera *Tribrachiocrinus* and *Phialocrinus* are no less remarkable for magnitude than for structural peculiarities; while a pygidium, on which the new species *Phillipsia grandis* is founded, "must represent a Trilobite nearly three inches in length, an exceedingly large size for a Carboniferous form." It is to be regretted that the conditions of sea-bottom that permitted such magnificent growth were not equally successful in the preservation of the fossils, which are for the most part nothing but the impressions and cavities left after the disappearance of all calcareous matter, a state in which accurate study is extremely difficult.

Of the animal-groups treated of in the present section of the Monograph, the most interesting are the Echinodermata. The species are few, Echinoidea being represented by two, Asteroidea by three, and Crinoidea by at most fifteen; while individuals are also rare, with the unprofitable exception of crinoid stem-ossicles, which, here as elsewhere, form large beds of Entrochal Marble.

The chief Echinoid specimen has been much damaged by fire, but enough remains to show a feature of some interest. "The rows of plates in each inter-ambulacral area are certainly four, but in the middle line of the three best preserved areas, between the two contiguous rows of tubercle-bearing plates, are smaller pieces devoid of tubercles." This species seems to connect *Archæocidaris*, which it otherwise resembles, with those allied genera that have more than four rows of interambulacrals: and when better specimens are known, it will probably form the type of a new genus. At present it is called *Archæocidaris*? *Selwyni*. This and an undetermined species of *Archæocidaris* come from the Upper Marine Series of the Permo-Carboniferous.

Australian starfish of the periods in question were formerly represented only by *Palæaster Clarkei*, De Kon. To this are now added two new species, *P. Stutchburii* and *P. giganteus*. In all these species, nearly the whole of the actinal surface of each ray is taken up by the ambulacral and ad-ambulacral plates, while the marginal plates are small and sub-dorsal, not actinal as in the true *Palæaster*. Mr. Etheridge, therefore, distinguishes these species by the new sub-generic name of *Monaster*. Palæozoic starfish are, however, in such a state of confusion that he would be bold who should predict whether or no this name will meet with final acceptance. These Asteroidea all occur in the Lower Marine Series, and *P. Clarkei* also in the Upper Marine Series, of the Permo-Carboniferous.

Among the Crinoidea are recorded numerous very doubtful fragments, such as plates of a species referred by De Koninck to *Actinocrinus polydactylus*, which are probably nothing of the kind; an internal cast supposed by Mr. Etheridge to belong to *Periechocrinus*, and actually named *P. indicator* as denoting the presence of that genus in Australia, a name which we cannot help thinking will turn out to be of the *lucus a non lucendo* type; some plates doubtfully referred to *Platycrinus*; some plates provisionally referred by De Koninck to *Poteriocrinus tenuis*, Miller, and *Poteriocrinus radiatus*, Austin, species which have since been relegated to *Scytalecrinus* and *Parisocrinus* respectively, and cannot, therefore, indicate the presence of *Poteriocrinus* as Mr. Etheridge seems to think; and finally several stem-fragments, which the author is kind enough to leave unnamed.

Mr. Etheridge has met with no specimen of the interesting *Symbathocrinus ogivalis* described by De Koninck, nor is any other instance of the genus recorded from Australia. We may, therefore, take this opportunity of mentioning that the dorsal cup of an allied species, from the Irwin River, W. Australia, has been sent home by Mr. H. P. Woodward, and will, it is hoped, be described in this MAGAZINE.

Some plates referred to *Platycrinus* are said to be "ornamented with radiating lines of very peculiar wart-like tubercles, concave at their apices." It seems to us very probable that these tubercles once bore spines like those of *Hystricrinus*, which is a Devonian form closely allied to *Platycrinus*, occurring in North America.

The remarkable genus *Tribrachiocrinus* is described afresh from the evidence of four species, of which two—*T. ornatus* and *T. granulatus*—are new. The dorsal cup in this genus is composed of three circlets of plates, viz., infrabasals, which are three, owing to the fusion of two pair; five basals, of large size and irregular shape; and five radials. In the posterior interradius are three plates, namely, the radianal, the anal *x*, and a plate between *x* and the right posterior radial resting on the radianal. Thus far the crinoid closely resembles *Eupachycrinus* and *Cromyocrinus* from the Carboniferous of America and Europe; but, turning to the arms, we find great peculiarities. In the anterior and in the left and right posterior rays, the radial has a wide articular facet (as in the genera just mentioned), on which works a wide brachial, usually narrowing above; this appears to have been followed in *T. ornatus*, which alone presents traces of arm-branches, by three more primary brachials the last of which supports two arm-branches; whether these latter branched again is uncertain. The left and right anterior radials, however, had no wide articular facet, but seem to have become fused with one or more of the primary brachials, and to have borne no regular arms. This view, to which Mr. Etheridge gives his support, resembles that of the earlier writers in that it ascribes only three main arms to the genus, and differs from that of Wachsmuth and Springer (which is misrepresented by Mr. Etheridge). To such a view there is no *a priori* objection, for much the same state of things is found in *Bærocrinus Ungerni*; at the same time it is hard to reconcile it with the figure of *T. ornatus* (plate xix.), which appears to show not six but at least ten series of distichals.

With reference to the tegminal plates of *T. corrugatus*, which Ratte described as vault-plates, but which Wachsmuth and Springer believed to be part of the disk, both parties were correct; for there is no difference between vault and disk.

As to the systematic position of *Tribrachiocrinus*, it may be pointed out that the Poteriocrinidæ of Wachsmuth and Springer included genera which, though they had arrived at a similar stage of evolution as regarded the anal area, seemed nevertheless to have sprung from two distinct stocks, one characterized by repeatedly dichotomous arms, as in *Poteriocrinus*, the other with arms in two main branches only, as in *Decadocrinus*. To these latter genera the name Decadocrinidæ has been applied, and among them there is at present reason to suppose that we must reckon *Eupachycrinus*, *Cromyocrinus* and *Agassizocrinus*, three forms that agree in the possession of a globose dorsal cup, large basals, a large radianal and a wide articular facet to the radial, characters, which, as we have seen, are also conspicuous in the cup of *Tribrachiocrinus* but not in that of *Poteriocrinus*. We regret therefore that Mr. Etheridge should prefer to retain the two latter genera in close association.

Phialocrinus is a name which Mr. Etheridge revives for the *Cyathocrinus Konincki* of De Koninck and three new species, *P. princeps, P. nodosus,* and *P. Stephensi.* The genus *Phialocrinus*, as Mr. Etheridge understands it, has a cup composed of five infrabasals, five basals, and five radials, with a pentagonal axal *x* truncating the posterior basal, in a line with the radials, and supporting two plates of the anal tube; its radials have a wide facet supporting two or three wide primary brachials, which bear in each ray two main arms. It is, however, advisable to point out that the arms, beyond the earlier distichals, are unknown in all the Australian species, and that the anal area also is unknown in *P. princeps*; it is therefore doubtful how far they agree with *P. patens*, Trd., which is taken as type of the genus. They certainly do not agree with *Scaphiocrinus simplex*, Hall, with which they are supposed to be congeneric. The whole question, however, involving as it does difficult points both of nomenclature and taxonomy, cannot be discussed in a review, and since we purpose describing a specimen allied to *P. Konincki*, we gladly defer till that occasion discussion of these and other interesting matters alluded to in the present Monograph.

Among Annelida there is only described one specimen, namely, a *Serpula*, to which is regrettably assigned a new name, apparently because it "is the first yet noted from the Permo-Carboniferous Series of New South Wales."

Turning to Ostracoda we find a rather doubtful new species described as *Carbonia australis*, and the description of *Entomis Jonesi*, De Kon. corrected; while the little bodies referred by De Koninck to *Polycope* are now supposed to be the fry of a species of *Aphania* or *Aviculopecten.*

The Trilobites of New South Wales do not extend above the Carboniferous. *Griffithides dubius*, Eth., senior, is now redescribed from older and better examples, and referred to *Phillipsia*; its axis has a peculiarly angular arch. There are also described *P. grandis*, n. sp., and some undeterminable fragments of both *Phillipsia* and *Griffithides.*

The difficulties of preparing such a book as this Monograph in a go-ahead country, far from libraries and fellow-workers, can hardly be appreciated by European students. Future parts would be improved if the author could dispense with a few misprints, such as "analagous," with the evidences of haste that occur in his quotations, and with such remarkable sentences as the following: "Waagen has described a species as *C. goliathus*, which, from his remarks, in comparing his detached plates with *P. Konincki*, certainly appear to place *C. goliathus* in congeneric relation with the Australian Crinoid." It is much to be regretted that all the plate-figures are reversed; on plate xvi. numbers 2 and 3 are interchanged, while we have wasted many weary minutes in discovering the orientation of figures 5 to 9. Having eased our feelings with regard to these easily avoidable defects, we may conclude by offering to Mr. Etheridge our thanks for, and felicitations on, the success that he has attained.

F. A. Bather.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 21st, 1892.—Prof. J. W. Judd, F.R.S., Vice-President, in the Chair.

The Chairman gave expression to the Society's deep sense of the loss which it had just sustained by the death of so distinguished a Fellow as Sir Richard Owen, who had been associated with the Society for no less than fifty-five years. He further announced that the Council, in causing a resolution of condolence to be forwarded to the bereaved family, had deputed Dr. Hicks and himself to represent the Society at Sir Richard's funeral.

In explanation of certain specimens of fossils exhibited by J. V. Parkes, Esq., F.G.S., and found in limestones about 11 miles north of Beltana Township, South Australia, Dr. G. J. Hinde said that the limestone slabs forwarded by Mr. Parkes were filled with the peculiar fossils belonging to the family Archæocyathinæ, which had been considered as probably allied to Perforate Corals. These fossils were widely distributed in rocks of Cambrian age in various parts of the world, having been found in Nevada, Labrador, Spain, and Sardinia, and they had lately been recognized in the same district in South Australia as that when Mr. Parkes specimens had been obtained, and an excellent description and figures of them were given by Mr. R. Etheridge, jun., in the "Transactions of the Royal Society of South Australia," 1890, pp. 10–23, pls. ii. iii.

The following communications were read :—

1. "On a Sauropodous Dinosaurian Vertebra from the Wealden of Hastings." By R. Lydekker, Esq., B.A., F.G.S.

In addition to *Hoplosaurus armatus* and *Pelerosaurus Conybearei*, there is evidence of another large Sauropodous Dinosaur in the Wealden, now known as *Morosaurus brevis*. Up to the present time it has been impossible adequately to compare *Hoplosaurus armatus* with *Morosaurus brevis*; but recently Mr. Rufford has sent to the British Museum an imperfect dorsal vertebra of a large Sauropodous Dinosaur from the Wealden of Hastings, which enabled the required comparison to be made. The Author describes the vertebra, contrasts it with that of *Hoplosaurus armatus*, and gives presumptive evidence that it should be referred to the so-called *Morosaurus Becklesi* (Marsh), which apparently cannot be separated from *M.* (*Cetiosaurus*) *brevis*. He has not been able to compare Mr. Rufford's specimen with the dorsals of the American *Morosaurus*, in order to discover whether the English Dinosaur is correctly referred to that genus.

2. "On some additional Remains of Cestraciont and other Fishes in the Green Gritty Marls, immediately overlying the Red Marls of the Upper Keuper in Warwickshire." By the Rev. P. B. Brodie, M.A., F.G.S.

The vertebrate remains occur in a very thin band of marly friable sandstone lying between two beds of green marl, though in some places the same bed has itself no admixture of sandy material.

Bones and teeth are so numerous that it might almost be called a bone-bed. It does not exceed three inches in thickness. It contains ichthyodorulites of Cestraciont fishes, abundant palatal teeth of *Acrodus keuperinus*, ganoid fish-scales, and abundant broken bones, some of which may belong to fishes, others to labyrinthodonts, and amongst the latter a fragment of a cranial bone.

3. "*Calamostachys Binneyana*, Schimp." By Thomas Hick, Esq., B.A., B.Sc. Communicated by J. W. Davis, Esq., F.G.S., F.L.S.

A number of preparations lately placed in the hands of the Author by Mr. W. Cash, of Halifax, give much additional information on many important points of detail connected with the structure and characters of the sporiferous spike known as *Calamostachys Binneyana*, and also throw considerable light on the question of its affinities. The Author fully describes the structure of the fossil, and discusses its systematic position. His description shows the close resemblance between the structure of this spike and that of *Equisetum*; and it is noted that Carruthers, in 1867, did not hesitate to describe *Calamostachys Binneyana* as the fruit of *Calamites*, and that Binney, when making it the fruit of *Calamodendron commune*, was in practical agreement with Carruthers. Williamson, however, realizing the difficulty of reconciling the supposed vascular central part of the axis of the spike with a Calamitean affinity, suggested that the relationship lies rather with the Lycopodiaceæ. Now the establishment in the present paper of the existence of parenchymatous pith in the axis of the spike removes the chief ground for Williamson's suggestion; and the demonstration of the existence of primary vascular bundles with carinal canals affords positive proof of the closeness of its relationship with the Calamitæ. The Author gives reasons for concluding that there is much probability that the fossil described in the paper is a spike of a *Calamites* of the type of *Arthropitys*.

4. "Notes on some Pennsylvanian Calamites." By W. S. Gresley, Esq., F.G.S.

The Author believes that a group of specimens from the Pottsville conglomerate series demonstrates that the so-called Calamite-casts in sandstone are not always to be regarded as casts of pith-cavity only, but are often casts of the vascular cylinder as well; also that these specimens show that some Calamites, at all events, possessed furrowed exteriors or barks. A specimen from the Pittston bed of anthracite in the Wyoming basin also seems to suggest that the true bark had not always a smooth exterior.

A specimen from the same geological horizon as the last specimen, and from a neighbouring locality, indicates a Calamite of gigantic proportions. Another specimen, from the Pittsburgh bed, is remarkable as showing two branch-scars not on, but below the nodes of the Calamite.

5. "Scandinavian Boulders at Cromer." By Herr Victor Madsen, of the Danish Geological Survey. Communicated by J. W. Hulke, Esq., F.R.S., For.Sec.G.S.

During a visit to Cromer in 1891 the Author devoted much attention to a search for Scandinavian boulders, and obtained three specimens; one (a violet felspar-porphyry) was from the shore, and the other two were from the collection of Mr. Savin. The first was considered to come from S.E. Norway, and indeed Mr. K. O. Björlykke, to whom it was submitted, refers it to the environs of Christiana.

The Author considered that the two specimens presented to him by Mr. Savin, who had taken them out of Boulder Clay between Cromer and Overstrand, were from Dalecarlia; and these were submitted to Mr. E. Svedmark, who compared one of them (a brown felspar-hornblende-porphyry) with the Grönklitt porphyry in the parish of Orsa, and declared that the other (a blackish felsite-porphyry) might also be from Dalecarlia.

II.—January 11th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "Variolite of the Lleyn, and associated Volcanic Rocks." By Catherine A. Raisin, B.Sc. Communicated by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The district in which these rocks occur is the south-western part of the Lleyn peninsula, marked on the Geological Survey map as 'metamorphosed Cambrian.'

Some of the holocrystalline rocks are probably later intrusions. The igneous rocks, which are described in detail in the present paper, belong to the class of rather basic andesites or not very basic basalts; they show two extreme types, which were probably formed by differentiation from an originally homogeneous magma. Corresponding to the two types of rock are two forms of variolite. These are fully described, and their mode of development is discussed.

The variolites occur near Aberdaron and at places along the coast. Their spherulitic structure often is developed towards the exterior of contraction-spheroids, and in this and in other particulars they correspond with those of the Fichtelgebirge and of the Durance. The volcanic rocks include lava-flows and fragmental masses, both fine ash and coarse agglomerate. They are associated with limestones, quartzose, and other rocks, which are possibly sedimentary, but which give no trustworthy evidence of the age of the variolites.

2. "On the Petrography of the Island of Capraja." By Hamilton Emmons, Esq. Communicated by Sir Archibald Geikie, LL.D., D.Sc., For.Sec.R.S.

The rocks of Capraja consist generally of andesitic outflows resting on andesitic breccias and conglomerates. The southern end seems to have formed a distinct centre of volcanic activity, whose products are younger in age and more basic in character than the rocks of the rest of the island, and may be termed 'anamesites.' The lavas appear to have flowed from a vent at some distance from the cone which probably occurred here and gave out highly scoriaceous fragments. In the other parts of the island andesite is almost everywhere formed, with patches of the underlying breccias here and there in the valley bottoms. The chief centre of activity probably lay west of the centre of the island.

Petrographical details of the andesites and anamesites, descriptions of groundmass and included minerals of each, and chemical analyses are given. As regards the age of the constituents, the Author arranges them in the following order, commencing with the oldest:—magnetite, olivine, augite, mica, felspar, nepheline.

CORRESPONDENCE.

THE ST. BEES SANDSTONE.

Sir,—In the short notice in the last number of the Geological Magazine, of Mr. Goodchild's paper on the above, read before the British Association at Edinburgh, I read that he considers the St. Bees Sandstone equivalent to the Bunter. I entirely disagree with him in this view. It is well known to those who are conversant with the Bunter Sandstone formation that it consists of the Upper Soft Red and Mottled Sandstone. The Pebble and Conglomerate beds and the Lower Soft Red and Mottled Sandstone, only the two lower divisions occurring in the North of England. These are well marked divisions, with beds totally unlike the St. Bees Sandstone.

I believe it to be much more probable that the St. Bees Sandstone is a large development of the Red Marls, Sandstones, and Gypsum beds that lie between the Upper and Lower Magnesian Limestone in Nottinghamshire and Yorkshire, and known as the "Permian Middle Marls and Sandstones." There is a break between these Sandstones and Marls and the Lower Magnesian Limestone quite as large as between the St. Bees Sandstone and the Magnesian Limestone and Penrith Sandstone. But breaks between two formations are often only local, caused by thinning away of beds, and there is really no great unconformity between the Bunter Sandstone and the Magnesian Limestone series (now called Permian) of Yorkshire, and I should not be surprised that in some locality it was found that the one passed up into the other. I will not quarrel with Mr. Goodchild for calling these lower formations "Lower New Red Sandstone" (the old term) though I do not like it, for in Yorkshire these beds are chiefly limestone, but I must protest against the St. Bees Sandstone being called Bunter, a formation, I consider, on a higher horizon. W. Talbot Aveline.

Oatlands, Wrington, Somerset,
December 5th, 1892.

ON THE SUPPOSED CONFLICT BETWEEN GEOLOGY AND PHYSICS.

Sir,—The late Dr. James Croll, while contending that there was ample proof from geology that conditions suitable for life on the Earth must have existed "far more than twice 20 millions of years ago"[1] (the narrow time limit of 20 million years only being supported by some physicists):—nevertheless Dr. Croll could not solve the following difficulty.

---

[1] Dr. Croll's paper in the Quarterly Journal of Science, July, 1877, p. 317.

If the earth (completely crusted over) have existed "far more than twice 20 million years," *à fortiori* then must the sun have been present longer than this period; for it is obvious that a habitable globe could not survive without the sun. But it is certain that if the sun have endured anything like this time, the contained store of heat must have been such—as Dr. Croll points out—that the solar nebula at that primitive age "would have extended beyond our Earth's present orbit, and of course our Earth could not at that time have existed as a separate planet" (Dr. Croll's paper in the Philosophical Magazine, May, 1868, p. 372). To infer the degree of expansion of the sun at that remote epoch, we have merely to deduce (an easy process) what the sun's temperature then was at his present rate of cooling.

Dr. Croll does not attempt to solve the difficulty he lays stress on; but is it not obvious, in view especially of the recent ideas as to space being[1] comparable somewhat to a "meteoric *plenum*," not to mention the continued other friction opposed to the flying globe—that the Earth's present orbit could not have been its original orbit? But the Earth must have come in an enormous distance towards the sun in over twice 20 million years, which is the lowest limit for the period which geology demands for the Earth's past existence, according to the evidence afforded by the known rate of deposition of sedimentary strata, etc. This kind of evidence is not vague, but mathematically convincing. Dr. Croll remarks, viz. "We have not sufficient data to determine how many years have elapsed since life began on the globe, for we do not know the total amount of rock removed by denudation; but we have data perfectly sufficient to show that it began far more than twice 20 million years ago" (Quarterly Journal of Science, July, 1877, p. 317).

So then we have the apparent fitness that then the sun was hotter than at present, the planets were further off. As the sun cools down, the planets approach him, this fact equalizing the conditions for life on the Earth over a far longer time-epoch than would otherwise be possible. This consideration affords apparently plenty of margin for past geological time, without coming into any conflict with physics.

The idea of a 20 million years' margin for the age of the sun's heat, enunciated by Lord Kelvin, depends on the assumption (in aspect arbitrary?) that the sun was formed by the gravitational approach of widely diffused matter in a primitive state of rest, for which "state of rest" we have surely no evidence. On the contrary, all analogy (all we observe in the skies now) goes to indicate that the matter whose collision formed the sun, was originally in motion. If this primordial motion naturally contributed to the heat developed at the concussion of such moving matter, whose encounter generated the solar heat: then any store of heat that geological time may require, could have been irrefragibly produced at the sun's formation.

---

[1] In a letter in "Nature," March 28, 1878, p. 243, on "The Age of the Sun's Heat in relation to Geological Evidence," an analogous solution to the above difficulty was offered by the present writer.

The necessity for the narrow 20 million years' margin, which clashes with geology, is seen then apparently not to have the slightest foundation. It rests on the gratuitous hypothesis that the sun's heat was derived *solely* from gravitation, entailing an approach of matter in a primitive state of repose. The quantity of heat generated under these premises was calculated originally by Helmholtz to suffice for 20 million years of solar radiation.

Moreover, the sun is not yet cooled down: so that a notable part of the 20 million years period, which is the inexorable limit of the above hypothesis, must be spread over *future* time. How much is left for *past* duration of the solar system and for geological history of our globe then? Neptune and Jupiter were certainly shed from the revolving-contracting solar nebula some millions of years before the Earth, *i.e.* before the Earth had a separate existence. Some millions of years must be then inevitably lopped off the other end of our already contracted time-margin. What is left over for the Earth's past existence then: so that on the (exclusive) gravitational hypothesis of the source of the sun's heat, no geological epoch worthy of that name would remain. S. TOLVER PRESTON.

HAMBURG, *Dec.* 14, 1892.

THE MOMMOTH AND THE GLACIAL DRIFT.

SIR,—I wish Mr. Jukes-Browne had devoted a little more of his last letter to Geology and a little less to offensive personalities. To these latter I do not propose to reply. What is alone interesting to your readers in this correspondence is to fix the exact age of the Mammoth, a matter of importance not only to the geologist but more especially to those devoted to the early history of man. To the settlement of this problem Mr. Jukes-Browne's last letter adds nothing. He reverts to two cases he had already quoted, one of them the well-known case at Hoxne, where, as I showed, there is not only no positive evidence forthcoming but which was riddled through and through by Mr. Flower. There can be no doubt whatever that judging by the published evidence the case of Hoxne breaks down. There is some evidence that at that place the drift beds overlie the Mammoth bed. There is none that will bear criticism that they underlie it.

The second case from Burgh, where it was not the Mammoth but the *Elephas antiquus* that was found, I have already criticized.

I must correct a curious delusion of Mr. Jukes-Browne, that on this question I have set myself against the best authorities. The best English authorities on the age of the Mammoth known to me are Professor Dawkins, Professor Geikie and Dr. Hicks,[1] all of whom virtually agree with me, or rather, I with them. The French geologists are almost without exception on the same side, while among the geological surveyors, to whom perhaps Mr. Jukes-Browne limits "authority," Mr. Lamplugh and Mr. Skertchly have been liberally quoted by myself, but as a mattor of fact authority has and ought to have very little place in geology any more than in any other science. Well attested facts and sound logic, combined if possible with literary courtesy, these are what, I am sure, your readers wish, and whoever brings them to your mill and helps to establish truth or sweep away error will be welcomed.

---

[1] See Dr. Hicks's letter.—EDIT. GEOL. MAG.

I trust I have avoided saying anything of which Mr. Jukes-Browne can complain, for I have profited a good deal from what he has written elsewhere. I have no wish to exchange sharp words.

Arley House, Lytham, near Preston. Henry. H. Howorth.
December 10*th*, 1892.[1]

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—The tone which Mr. Jukes-Browne has thought it advisable to adopt in his attacks on Sir Henry Howorth, in recent Numbers of the Geological Magazine, does not, I hope, commend itself generally even to the official mind, still less will it to those who, like myself, believe that it always has been and will still be to the advantage of geological science that it should be cultivated by others than those who have been made geologists by Act of Parliament, or who have adopted it as a profession.

Pending the appearance of the "man who has acquired an insight into the subject by long experience and by approved practical work in the field," (he does not say by whom or by what authority the work is to be approved) who will some day settle the question "beyond dispute." I should like to ask Mr. Jukes-Browne by what rule of evidence could he expect Sir Henry Howorth to accept "as final" the imaginary case he cites, viz. "Gravels with Mammoth bones resting on Boulder-clay." Surely in the first place he should point out a typical case, so that an opportunity may be given for critically examining the evidence. But let it be granted that he could point out such a case, how is it to be proved that the remains, which are those of land animals, are to be considered as of contemporaneous age with the gravels, and not as having been derived either from an earlier deposit, or directly from an older land surface? The only evidence that could be conclusive would be the finding of Mammoth remains, *in an undisturbed state*, on an old land surface with undoubted glacial deposits below it: such a surface as that on which the Endsleigh Street remains were found, but not having, as there, only pre-glacial beds below but some typical glacial deposits instead.

I have already pointed out that Mammoth remains were found by me in caverns in the Vale of Clwyd, under undoubted glacial deposits. I have this year obtained a fragment of a tibia of a Mammoth from the Lower Glacial Gravel at Finchley in a section where a great thickness of Chalky Boulder-clay, containing the well-known derived fossils, reposed on the gravel. The Endsleigh Street evidence, in my opinion, is equally conclusive in showing that the Mammoth lived there early in the Glacial period. The foregoing and similar cases which have been recorded can only *prove* that the Mammoth lived in this country, or in the districts in which the remains were found, during a part of or before the Glacial period.

Hendon, *Dec.* 8, 1892.[1] Henry Hicks.

[1] Publication delayed by special request of Correspondents.—Edit. Geol. Mag.

GRANITE.

Sir,—I can only express amazement that such a paper as that of Mr. T. R. Struthers on Granite (Geol. Mag. 1892, p. 561–4) should have been written in the year of grace 1892.

Mr. Struthers begins by attributing to geologists the absurd theory that the supposed granitic foundation of the Earth's crust was formed after the overlying crust itself. A perusal of pages 86 to 88 of Rosenbasch's paper "Zur Auffassung des Grundgebirges"[1] would have shown the groundless nature of this statement.

Then follows a delicious example of a *non sequitur* in the observation "that erupted rocks, whether volcanic or trappean,[2] have apparently been derived from granite, for in common with them it consists mainly of silica, alumina, potash, soda, lime, magnesia, and iron." Why granite, to the exclusion of syenite, diorite, gabbro, peridotite, etc., is to arrogate to itself the honour of being the mother of all erupted rocks is not even supposed to require explanation.

Then we have a quotation of a most unfortunate remark of Beete Jukes (no page or reference given; I find it in the 2nd edition of his Manual of Geology, 1862, omitted apparently in the 3rd edition, 1872), from which Mr. Struthers evidently concludes that any lava stream, of no matter what chemical composition, could be traced within the earth to granite. Let the petrologist imagine tracing a limburgite lava stream to a granite magma.

Mr. Struthers states that "the hydrothermal conditions under which granite was formed . . . were peculiar to a particular period of the world's history, when a sea of high temperature overspread its entire surface before any dry land had appeared." Anything more contrary to known facts than this statement can hardly be imagined. The Dartmoor granite and the Brocken granite alter rocks of the Carboniferous period. Does Mr. Struthers suppose that no dry land had appeared at that period or that the fish of those days swam about in boiling water?

He has no hesitation in saying (apparently only from the examination of Lyell's figure (Elements, 1874, p. 552) that the granite of Sharp Tor, Cornwall "is a fine example of bedded granite originally discharged in successive submarine sheets."

Unfortunately Lyell does not state the scale of his drawing, otherwise Mr. Struthers would probably see the untenable nature of his interpretation of the well known mural weathering of granite. An examination of the rock of the apparent pile in question would probably show under the microscope complete continuity in the unweathered portions between the seemingly separate lenticles. If Mr. Struther's interpretation of mural weathering were correct the lenticles should be of immense size, whereas every one practically acquainted with the subject knows that they thin out or are discontinuous usually in a distance of a few feet. Bernard Hobson.

Owens College, Manchester, *Dec.* 19*th*, 1892.

---

[1] Neues Jahrbuch für Mineral, 1889, Bd. ii.

[2] Mr. Struthers still classifies rocks into, among other groups, "trappean" and actually calls syenite a trappean rock.

3000 FEET OF QUATERNARY AND ? TERTIARY DEPOSITS IN TEXAS, U.S.A.

Sir,—At Galveston, Texas, a well has recently been bored (in search of water for a city supply) in which the following formations are reported (in the New York "Engineering and Mining Journal") to occur. This well is said to be the deepest on the sea-coast of the United States.

From surface to	46	feet	......	Grey sand.
Thence to a depth of	64	,,	......	Red clay and shells.
,,	100	,,	......	Blue clay, sea shells, and rotten wood.
,,	315	,,	......	Sands and sea shells.
,,	815	,,	......	Sand and clay.
,,	1288	,,	......	Sand, clay, sea shells, and decayed wood.
,,	3070	,,	......	Varying strata of sand, clay, and large logs.

At very bottom of hole a bed of Sea shells was struck.
The diameter of the hole varied from 15 to 6 inches.
No water and no rock were encountered.

Perhaps this may meet the eye of someone who can supply more detailed information in regard to this interesting section, and say something as to the nature of the sea shells, fossil wood, etc., brought up.

W. S. Gresley.

Erie, Pa., U.S.A., *6th December*, 1892.

"THE MALVERN CRYSTALLINES."

Sir,—May I be allowed to make one or two brief remarks on the criticism of my friend, Dr. Calloway, in this month's number of the Geol. Mag.

While attaching a very high value to his work, I still fancy I have broken new ground to some extent by presenting the case of the Malvern Crystallines as a *physical* problem to be attacked, first of all in the light of the field-evidence, for observing and collecting which I had exceptional opportunities in the early part of the year. I may say that his general omission from consideration of the chemical and physical factors of such a problem takes the sting out of many of Dr. Calloway's criticisms. I cannot regard it as a valid criticism to quote from what is little more than a note in Prof. Phillips' later work, as if it neutralized the value of the speculations of his earlier work, to which I referred. It does not alter my estimate of the value of his earlier views, which went so far in anticipation of some recent advances in petrological science. Does Dr. Calloway think he is appealing from Phillips' drunk to Phillips' sober? Nor does a negative deduction from Dr. Callaway's general experience of the Malverns do much to damage a case specifically cited by me in the quarry above West Malvern Church. Creditably again is so variable a factor with different minds, that such a retreat from the objective to the subjective does not appear to me to be of a very high order of scientific reasoning. The puzzling case of the hornblende and the two felspars mentioned on p. 546 seems to me (so far as I can follow the description) to admit of an easy explanation as a case of pure and simple segregation as crystallization progressed in the mass, if the variable fluxing-action of the different bases is fully considered, and to which I have drawn attention in my paper.

I do not for a moment pretend to have reached the end of my studies of this interesting complex of rocks, and shall await with much interest the appearance of the promised paper. As to my 'shear-planes' (not 'shear-zones'), it is just *because they have nothing to do with the 'schist-making' processes,* that they afford such strong *negative* evidence (while they record the action of dynamic forces on a grand scale) against the notion of the schist-manufacture having been wrought generally in *solid* crystalline masses. The general principles of my work are sufficiently before the world for those who care to know them to do so.

Wellington College, Berks, 16*th Dec.*, 1892. A. Irving.

GLACIAL GEOLOGY.

Sir,—I quite agree with Mr. R. M. Deeley in your last number, when he writes that he has "read with much interest the papers by Mr. Mellard Reade and Mr. Percy Kendall in your July and November issues. On the one hand we have the submergence theory proved up to the hilt, and on the other, the glacier theory sustained with equal show of reason. Does it strike the combatants that they may both be right and both be wrong?"

It is difficult to conceive a Glacial Period without the usual phenomena appertaining to both land and coast ice. Why should we, therefore, restrict ourselves to either the one agency or the other, when there must have been marine and land moraine drifts contemporaneously forming. The Gloppa deposit at Oswestry described by Mr. Nicholson in the Q.J.G.S. Vol. xlviii. p. 86 may be taken as a typical marine drift with its glaciated lake district erratics and Boreal Fauna of recent shells, occurring from 1070 to 1120 feet above O. D., yet twelve miles to the north-west of the Gloppa in the upper valley of the Dee from the neighbourhood of Corwen to Bala Lake, which is only 540 feet above O. D.—the drift is entirely local and does not contain any fragments of recent marine shells, though 500 feet below the Gloppa deposit.

The plain interpretation of this—to my mind—is that ice filled the upper valley of the Dee and the surrounding country to a higher level than that to which the marine drift of the Gloppa obtained. The Gloppa deposit like the other deposits of high level marine drift as Moeh Tryfean, Macclesfield, and Halkyw (Flintshire), are situated upon the outskirts of the mountainous areas to which they belong. This, I think, would suggest that such mountainous areas were covered with a thickness of ice in their central portions, which excluded the high level marine drift from the interior mountains and valleys. William Shone.

Upton Park, Chester, *Dec.* 16*th*, 1892.

OBITUARIES.

JAMES ARMSTRONG, FORMERLY OF GLASGOW.

Born January 1, 1832. Died Nov. 28th, 1892.

James Armstrong was born at Leith, on the Firth of Forth, Scotland, but was educated at a Normal School in Glasgow, where, at an early age, he was sent into a business office. He had from his youth a keen desire for study, and joined an evening class at Anderson's College, Glasgow, under Dr. Taylor, professor of Natural History. Soon afterwards he, with a few of his colleagues, founded the now well-known Glasgow Geological Society, of which he was for many years its Recording and Corresponding Secretary, and Editor of its Transactions. Mr. Armstrong was an ardent Collector of fossils, especially those of the Carboniferous rocks, and he was one of the best authorities upon the fossils of this formation in the West of Scotland.

In conjunction with Mr. John Young, F.G.S., of the Hunterian Museum, Mr. Amstrong published in 1871, a "Catalogue of the Carboniferous fossils of the West of Scotland," printed by the Geological Society of Glasgow. Later (in 1876), with the assistance of John Young and David Robertson, F.G.S., and Professor J. Young, M.D., these geologists brought out an admirable little work, being a "Catalogue of the Western Scottish Fossils," with figures of the Moffat Graptolites by Prof. Lapworth, and an admirable Bibliography, printed and published at the expense of the Local Executive Committee of the British Association for the Glasgow Meeting, 1876. Mr. Armstrong's private collection was one of the best illustrations of the palæontology of the Glasgow area, and is now preserved in the Museum of Science and Art, Edinburgh, while a small part is in the Cabinet of Dr. Hunter, of Carluke, Lanarkshire. Mr. Amstrong was a Member of the Glasgow Philosophical Society, of the Edinburgh Geological Society, &c. He died at Brooklyn, New York, U.S.A., on the 28th November, 1892.

PROFESSOR JOHN STRONG NEWBERRY, M.D.,

FOR. MEMB. GEOL. SOC. LOND.,

Born December 22, 1822. Died December 7, 1892.

Professor J. S. Newberry, of Columbia College, New York, whose death we regret to have to record, was born seventy years ago at New Windsor, Connecticut, and removed early in life to Cuyahoga Falls City, in Ohio. He was educated for the medical profession, and graduated in 1846 at the Western Reserve College, and afterwards at Cleveland Medical College in 1848. He travelled in Europe in 1849–50, and entered upon private practice as a physician at Cleveland, Ohio, in the year following.

Newberry was imbued from childhood with a taste for Natural

Science, and the routine of his profession soon proved too irksome. In 1855 he determined to devote all his time to scientific work, and started as surgeon, geologist, and naturalist to the Government expedition under Lieut. Williamson, engaged to explore the country between San Francisco and the Columbia River. Newberry soon after published his first work on "The Geology, Botany, and Zoology of North California and Oregon." In 1857–58 Newberry explored the now well-known cañons of the Colorado River, and shortly after prosecuted his geological researches in New Mexico, Arizona, and Utah.

Newberry's distinguished services were rewarded in 1866 by the post of Professor of Geology in the School of Mines, Columbia College, New York, and two years later he was made State Geologist of Ohio, when his more systematic scientific work began. The reports of the Geological Survey of Ohio, published under his direction, contain not only stratigraphical and economic geology, but also monographs on palæontology of great value. The descriptions of the Devonian and Carboniferous fishes and plants were contributed by Newberry himself; and these, with subsequent writings on the same subject, led to an entirely new view of the gigantic "placoderm" fish, *Dinichthys*, of the Devonian period. His unique collection has been placed in the museum of Columbia College.

Although Professor Newberry continued his lectures and classes until two years ago he nevertheless found time to pursue his favourite studies on Palæozoic and Mesozoic fishes and plants, and in 1888 and 1890 he issued two large monographs under the auspices of the United States Geological Survey. The first volume relates to the Triassic fishes and plants of New Jersey and Connecticut, and the second deals with various Devonian and Carboniferous fishes, each containing a synopsis of earlier researches, combined with new figures and many observations not previously published. These works will ever remain standards for reference, and the mine of clearly-enunciated facts they contain will form an enduring monument of the author's industry and acumen. Even until the last, Dr. Newberry was contemplating a supplementary volume on the Palæozoic fishes, and he had nearly completed a Monograph on the Cretaceous flora of New Jersey.

Dr. Newberry was one of the founders of the United States National Academy of Sciences, and occupied the Presidential chair of the New York Academy of Sciences from 1867 until 1891. In 1867 he presided over the meeting of the American Association at Burlington. In 1883 he became a Foreign Member of the Geological Society of London, and in 1888 he received the Murchison Medal awarded by that Society. Whether in his quiet home at New Haven, or in the Museum of Columbia College, or wandering abroad, the privilege of meeting Dr. Newberry was one to be cherished. He was truly esteemed by all who came in contact with him, and the memory of his friendship will long be treasured, both by his students and fellow-workers.

THOMAS DAVIES, F.G.S.

BORN DECEMBER 29, 1837. DIED DECEMBER 21, 1892.

BY the death of Mr. THOMAS DAVIES, Senior Assistant in the Mineralogical Department of the British Museum (Natural History), Mineralogy in this country loses one of its most accomplished students. He was the son of the late Mr. William Davies, for forty years connected with the Geological Department of the same Museum, and began his career as an Attendant under Professor Maskelyne in 1858. For several years Davies was the only member of the Museum staff deputed to assist the Professor in arranging the collection of minerals after its severance from the Geological Department, and he rapidly acquired that knowledge of mineral species for which he became so noted in later years. In 1862 he was promoted to the rank of Transcriber, and in 1880 he received the well-merited reward of appointment to a senior assistantship. Mr. Davies was a prominent member of the Mineralogical Society, acting for some years as Editor of the "Mineralogical Magazine," and later filling the office of Foreign Secretary. Besides mineralogical notes, he published several contributions to the petrology of the older rocks, and in 1880 he was awarded the Wollaston Donation Fund by the Geological Society of London, "as a testimony of the value of his researches in mineralogy and lithology, and to assist him in the further examination of the microscopial structure of rocks." Although not a copious writer himself, Mr. Davies was well-known for the valuable assistance and information he was ever ready to afford to others, and it was in this capacity that he won the thanks and regard of so many geologists.

A Memorial on behalf of his widow and family, initiated by the Members of the Mineralogical Society, is, we understand, in progress, of which Dr. Hugo Müller, F.R.S., V.P.C.S., 13, Park Square East, Regent's Park, N.W., is Treasurer, and Mr. Henry A. Miers, F.G.S., F.R.S., of the Mineral Department, British Museum (Nat. Hist.), Cromwell Road, S.W., is the Secretary.

MISCELLANEOUS.

A REMARKABLE SPRING IN LINCOLNSHIRE.—An extraordinary success in artesian-well-boring has just been accomplished at Willoughby, in Lincolnshire. Owing to an inadequate water-supply for the locomotives running on the Sutton and Willoughby Railway, the Company decided to bore. At a depth of 245 feet from the surface the workmen struck upon a bed of ironstone, which took them a considerable time to penetrate, but beneath this rock a magnificent spring was met with. For some time the water threw out tons of blue sand, but it eventually cleared, and it now flows over the top of a $2\frac{1}{2}$ inch tube 30 feet above the ground at the rate of 4619 gallons per hour, or $1\frac{1}{4}$ gallons per second. The spring is said to be the strongest yet obtained in Lincolnshire.—*Morning Post,* January 25, 1893.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. III.—MARCH, 1893.

ORIGINAL ARTICLES.

I.—Measurement of Geological Time.

By T. Mellard Reade, C.E., F.G.S.

MANY ways of measuring geological time have been attempted by various geologists of eminence; but however diverse their methods, so far as I know, all finally hinge upon either the rates of denudation or accumulation. It is urged as an objection to this that in past ages such actions have gone on more rapidly, and therefore the calculations based upon present rates are valueless. Physicists on the other hand have sought to put a limit to the age of the earth much below what geologists generally demand. Reasoning from certain data which are necessarily more or less hypothetical, they say, that from the thermal condition of the globe at present, it cannot be more than from ten to twenty million years since it was at a temperature in which life on it would have been impossible. Geologists can hardly be blamed if they attach greater weight to their own observations and data and to reasoning that is more familiar and appears more certain and satisfactory to their minds.[1]

It is, however, quite unnecessary for me to elaborate this point, as Sir Archibald Geikie has so lately dwelt upon it in his usual lucid and telling manner.[2]

It appears to me after long study and various attempts on my own part to approximate to the length of geological time that the difficulty of getting at a satisfactory system of calculation does not arise from the unreliability of assumed rates of denudation, but from the want of a principle which will eliminate uncertain phenomena. If our modulus is the maximum thickness of all the formations we are naturally met with the objection that such a pile of strata nowhere occurs in nature. If we take as our gauge the actual thickness in any one place it may be reasonably objected that 10 feet of one set of strata may chronologically represent 1000 feet or more of another. In addition to this, how can the hiatus represented by unconformity be estimated? If, again, we start with the average thickness of the sedimentary rocks as our principal measure, it is obvious on the slightest consideration that this will give a result much below the actual time, as the particles of such sedimentary rocks have been used up over and over again, and to reach a correct result the number of years which it would take to directly produce this sediment must be multiplied by the number of times the particles have been used. Let us see if we can apply these considerations in estimating a section of geological time.

---

[1] Since this was written Mr. Clarence King's paper ("The Age of the Earth," Amer. Journ. of Science, Jan. 1893), proves the final exception to the rule.

[2] Presidential Address to the British Association, Edinburgh, 1892.

For the sake of precision we will commence at the base of the Cambrian, as the underlying Archæan rocks are involved in some obscurity, though of late years a very considerable advance has been made towards their interpretation.

A MODE OF ESTIMATING THE TIME THAT HAS ELAPSED SINCE THE BEGINNING OF THE CAMBRIAN.

Area of Denudation entering into the Calculation.

Our point of departure being the time when the first Cambrian sedimentation began, it will be clear on a little consideration, that at the commencement, the area of denudation was necessarily the whole of the then land area of the globe, which for our calculation we will assume to have been of the same extent as now. But as time progressed and fluctuation of levels and mountain building began, these Cambrian sediments became land, and to a large extent supplied the sediment for succeeding formations. Thus the Silurian would be partly formed from the *débris* of the Cambrian, the Devonian from the Cambrian and Silurian, and so on through Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eocene, Miocene, Pliocene, and Quaternary. It is thus evident that the pre-Cambrian rocks, as they became covered with newer rocks, must have supplied sediment to the succeeding formations in gradually decreasing proportion. What mean proportion these exposures of pre-Cambrian rocks throughout the time that has elapsed from the Cambrian inclusive to the present, bore to the total land area of the globe must be largely a matter of conjecture; but to these exposures, for our purposes, must be added all igneous rocks which have come to the surface since, and have by their denudation added to the post-Cambrian sediments. For the sake of our calculation we will assume that the pre-Cambrian and igneous rocks throughout this time were as a mean one-third the area of the whole land of the globe. This then will constitute the area of denudation, or quarry, so to speak, yielding the materials for building up the post-Archæan rocks, the other two-thirds being Cambrian and succeeding rocks yielding no fresh materials to increase the bulk of post-Archæan sediments.

Actual bulk of the sediments which have accumulated since the beginning of the Cambrian.

There are several difficulties in estimating the *actual* bulk of the sedimentary rocks of the globe. These difficulties are of two kinds, as follows:

First as to thickness. It is usual in geological works to give the thickness compiled from the areas where the maximum development of the various formations occurs. Of course every geologist knows that at no one place on the earth's surface do all the formations occur together, much less in their greatest development. To put the case clearly from the point of view of the present paper, if a series of borings were made over the great continents down to the base of the Cambrian, so as to enable us to estimate the mean thickness of all the sediments laid down since the beginning of the Cambrian, we should get the figures we require for our calculation. I am afraid that this is not likely to be done, at all events at present, either for scientific purposes, or by the wildest company promoter. We must therefore be content to adopt a minimum thickness. Considering that we have colliery sinkings all in one formation over half a mile deep, and numerous borings of half a mile, and one of a mile, through sedimentary rocks in various places, without reaching the Cambrian base, few geologists will cavil if we take the average thickness of the earth's sedimentary crust down to the Cambrian base at one mile.

Second as to area. In estimating the area of the sedimentary rocks, we are met with the difficulty that we have no actual proof of their extent under the ocean bed. There are two extreme, and some intermediate, opinions held by modern geologists. The one claim that sedimentary rocks underlie all the oceans, the other that they extend only a limited distance from the present coast-lines. It is, however, clear that the most strenuous advocate of the permanence of Ocean Basins will admit that there is sediment of one kind or another over the whole ocean bottom, though he is led from various considerations to believe that it has never formed land. Still it is sediment in part to be legitimately claimed as entering into our calculation of geological time.

For the purposes of this paper I will, however, take the bulk of post-Archæan sediment in and under the ocean as equal to that on the present land area of the globe, or, to state it in other words, the post-Archæan sediments of the whole globe are equal to the present land area two miles thick.

Rate of Erosion of Igneous Rocks.

There appears to be a concensus of opinion that one foot in 3000 years is a fair estimate of the mean rate of sub-aerial erosion over all land areas throughout all geological time. I am prepared to adopt these figures for Archæan and igneous areas also, though they are probably considerably in excess of what occurs now, the mean rate of erosion of igneous and gneissic rocks being less than the mean rate of erosion of sedimentary rocks, as is proved by their usually standing up as bosses amongst sedimentary rocks which have been stripped from them by denudation.

CALCULATION OF THE TIME WHICH HAS ELAPSED SINCE THE COMMENCEMENT OF THE CAMBRIAN.

The calculation now is a very simple one. The mean area of denudation throughout post-Archæan times being taken as one-third the entire land areas of the globe, the bulk of the post-Archæan rocks being expressed by the land area of the globe two miles thick, and the rate of denudation one foot in 3000 years, the time of accumulation will be $5280 \times 2 \times 3000 \times 3 = 95,040,000$. *The time that has elapsed since the commencement of the Cambrian is therefore in round figures 95 millions of years.*

CONCLUDING REMARKS.

Although the foregoing computation of post-Archæan time is on a different principle to that adopted by Sir Archibald Geikie in his Presidential Address to the British Association referred to, it is satisfactory to find that the results come out much the same. It has been objected to the latter method that deposition goes on much more rapidly than denudation, because it is assumed by those who hold this opinion that material which is denuded is spread over a much smaller area than that from which it was derived, consequently it must accumulate more rapidly. Checked by the method adopted in this paper it would appear that the earth's age geologically speaking must be, as inferred in the Presidential Address, somewhere between 100 million and 600 million years.[1]

This is a large margin no doubt, but it is an important thing to know. Different men may put different values on the three factors, bulk of sediment, rate of denudation, and area of denudation; but I think a fair and impartial examination of the reasoning involved in this paper will show that the principle of the calculation is sound.

II.—ON OOLITIC AND OTHER LIMESTONES WITH SHEARED STRUCTURE FROM ILFRACOMBE.

By FREDERICK CHAPMAN, F.R.M.S.

(PLATE V.)

Introduction.

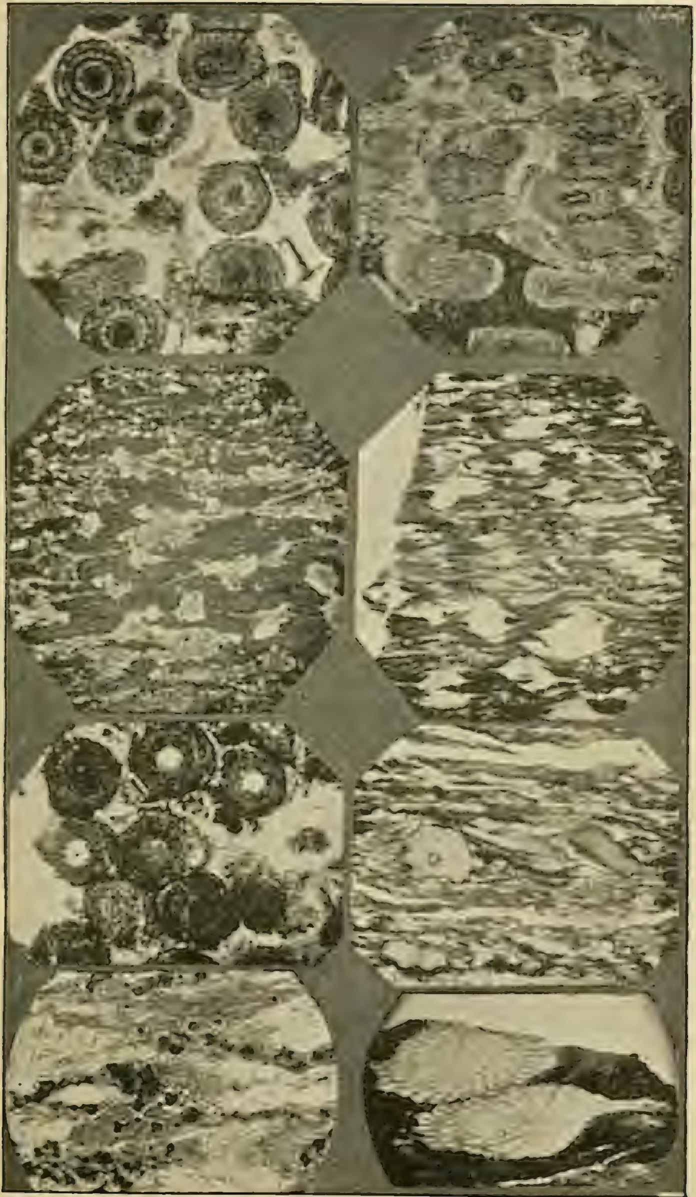
IN 1886 the author, during a visit to Ilfracombe, obtained some specimens of Middle-Devonian limestones which, at the time of collecting, he supposed to be formed of *Syringopora*, on account of the granulated weathered surface, and especially since the coral named had been recorded from the locality.

After revisiting the spot in 1890, and making a somewhat extensive collection therefrom, principally for the hope of finding micro-organisms, this particular rock again attracted his attention by the peculiar granulate surface produced by weathering. A section of the rock was made which proved it to be a good example of a limestone formed of oolitic grains. Subsequently a series of specimens showing shearing in all stages was found, and these were capable of being traced back to their original source in the rock with oolitic structure.

It is the main purpose of this account of the limestones to point out the interesting changes due to dynamical and chemical agencies, in the form of shearing, silicification, and the growth of dolomite

---

[1] It must not be forgotten that to arrive at the earth's age Archæan time has to be added to my estimate of 95 million years, which very materially increases the margin of geologic time on which we are allowed to draw.



R. S. Chapman, photo. Swain sc.

Sheared Limestones from Ilfracombe.

and other crystals, which have taken place in the rocks of this district.

Description,—The limestones which appear to be in their least-altered condition are some encrinite-limestones from the east side of Hele Strand, and the cliffs at Hagginton Beach; and also others formed entirely of *Cyathophyllum cæspitosum* and many other species of Rugose corals, occurring in lenticular masses in the slates of Hagginton Hill. In these limestones, nevertheless, solitary quartz and dolomite crystals can be often seen, though the latter mineral makes its appearance in any abundance only in those rocks which have been subjected to pressure. In the specimens obtained from the neighbourhood of Rillage, and on to Watermouth, the dolomite occurs well crystallized although it performs a subordinate part in forming the mass of the limestone; but nearer to Combe Martin the rocks become completely dolomitized, where here and there, in a microscopic section, one meets with a stem-joint of an encrinite or other organism which points to the origin of the mass.

The oolitic limestone before mentioned occurs over Sampson's Cave, which is about 300 yards east of Rillage; but the rock was inaccessible *in situ,* though tumbled blocks of it were obtained at the mouth of the cave at low water. The same kind of rock was also found in freshly broken blocks at Watermouth Cave, about three-quarters of a mile to the east of Sampson's Cave. The oolitic rock is of a dark blue-grey colour, and the separate granules which weather out at the surface are quite black. Some of the specimens of this rock from Sampson's Cave have not, apparently, been subjected to much pressure, though all that were obtained show a greater or less tendency to cleave. The granules, under the microscope, are seen to be formed upon a nucleus of a shell-fragment or sometimes a quartz-grain; and they are perfectly spherical in the plane of cleavage (where such exists), and nearly so at right angles to it. The oolitic granules were found to be much harder than the surrounding matrix, when polishing a section of the rock on a snakestone; the granules standing out in relief. This hardness was found to be due to the almost entire replacement of the original grain by microcrystalline quartz. Fig. 1 shows the oolitic structure before the distortion of the granules; the latter are circular in outline and $\frac{1}{28}$ inch (·925 mm.) in diameter. Around the grains may be seen a transparent boundary or fringe with a ragged margin, which is an outgrowth of the pseudomorphous or secondary quartz replacing those grains. When the section of the rock is examined under a high-power (*i.e.* $\frac{1}{4}$ inch), innumerable crystals of iron pyrites can be seen, showing triangular, square, pentagonal, and hexagonal outlines, and occurring disseminated through the oolitic grains in isolated crystals, without any regard to the concentric structure of the former; and also in the matrix in patches and strings, filling up incipient rifts and cracks. The blue-grey colour of the limestone and the dark tint of the granules is due to this occurrence of the iron pyrites; and the mineral performs an interesting part in the subsequent alteration of the rock, as will presently be seen.

Fig. 1*a* is from a specimen which has been boiled in HCl before preparing the microscopic section from it, so that only the silica and iron pyrites are left. It will be seen that the spaces between the grains, and occasionally the centres of the latter are dissolved out, showing that a very small proportion of the original rock exists in this oolite.

Fig. 2. represents a section taken from a slightly cleaved limestone, and in a direction vertical to the cleavage, from Watermouth Cave. In this example we have the first definite appearance of shearing in the rock. At this stage the grains have only suffered slight flattening, without much distortion, but irregular fissures have been made in the mass, passing through both grains and matrix in sinuous, but roughly parallel, lines. This specimen is also more or less silicified.

At the next stage, shown in Fig. 3, there has been a great change in the structure of the rock-mass; it has been subjected to such pressure as to have caused the oolitic grains to be lengthened out to a remarkable degree, and to closely overlie one another. The length of the grains in this condition is nearly twice the probable original diameter, and the proportionate length and breadth as 5 to 1. A siliceous fringe is seen bordering these lengthened grains, when viewed between crossed nicols, but the silicification does not apparently affect the grains themselves, since a section, decalcified upon the slide, which had been cut from this rock, exhibited after the treatment dolomite crystals with a little silica around the precincts of the grains, but showing that the grains themselves had been dissolved out. It therefore appears evident that the silicification of the limestones has only happened in the case of those oolitic rocks which have escaped shearing, or which have only been slightly acted upon by pressure. In the lengthened-out grains of this specimen, the concentric layers of the oolitic grains can be distinctly seen, as can also the radial structure which is so characteristic of the older oolitic rocks. The dolomite crystals occur in lenticular strings, the centre of each lenticle being occupied by granular material (perhaps ankerite), whilst on the outer margin are very well-developed crystals of dolomite often showing zone-structure. Seen under a high power these dolomite crystals show inclusions of very minute particles of iron-pyrites, and this latter mineral also occurs in some abundance in the fissures formed by the shearing of the limestone.

In a hand-specimen this rock is of a dark blue-grey colour, with a distinct schistose structure; and traversing it, generally at right angles to the plane of schistosity, are numerous veins of pure white calcite, representing faults produced by the folding and crushing of the beds.

An analysis of this dolomitized limestone has been made for me through the kindness of Prof. Thorpe, F.R.S., by Mr. Ernest A. Pinchin, in the Chemical Laboratory of the Royal College of Science, and is as follows:—

ANALYSIS OF DOLOMITIZED LIMESTONE (dried at 100° C).

Calcium carbonate ($CaCO_3$)	74·88
,, sulphate ($CaSO_4$)	0·24
,, phosphate ($(Ca_3PO_4)_2$)	trace.
Magnesian carbonate ($MgCO_3$)	14·95
Ferrous carbonate ($FeCO_3$)	4·75
Insoluble (SiO_2)	5·06
Total	99·88

As sulphide of iron is present in the rock it would appear that in the analysis it is represented by the other iron and sulphur compounds.

The extreme condition of the sheared rocks found is shown in Fig. 4, from a specimen collected at Rillage Point. In this specimen the grains are drawn out to about ten times their present breadth. In one instance a grain was affected by the shearing force on a portion only, one side having been drawn out whilst the opposite side exhibits the almost circularly concentric layers of the grain. In this rock we see, besides the lengthened and contorted grains which give an appearance of fluxion structure to the mass, numerous well-formed crystals of dolomite disposed along the lines of cleavage, and which are stained by ferruginous material; also "eyes" of calcite, which can be traced to their origin as portions of joints and ossicles of crinoids.

Fig. 4*a* is from a more highly magnified photograph of the same kind of rock, but from a different specimen. In this we see the decomposition which has taken place in the included iron pyrites, and the subsequent hydration, giving rise to a brown staining which in most cases obscures the centres of the dolomite crystals and in rarer cases brings out their zone-structure. The rock itself is of a rusty-brown colour instead of the dark blue-grey colour of the fresher kinds.

Fig. 5 is taken from a rock collected at Rillage Point, and differs somewhat from the preceding series on account of the scarcity of the sheared granules and abundance of calcitic fragments and encrinite remains. In this rock there is no dolomite, and its absence is quite exceptional. The organic remains, it will be seen from the illustration, are conspicuously unaffected by the shearing, whilst the oolitic grains are very much attenuated.

Fig. 6. is from a section taken across the coralla of *Cyathophyllum cæspitosum* in a limestone formed of that coral. The attenuated form of these coralla is probably entirely due to the shearing action upon the rock. This specimen was obtained from Watermouth.

Conclusions and Suggestions.—Although the sheared oolitic limestones were all found in the immediate neighbourhood of Rillage Point, whilst the less altered specimens were obtained from localities to the east of that place, it is highly probable that further investigation will show that the comparatively unaltered oolite alternates with the sheared rock; that is to say, according to the evidence afforded all along this part of the coast of the excessive crumpling and crushing of the strata, it is only reasonable to suppose that the different stages of this sheared rock recur at intervals according to their position in the plications where they have suffered greater or less pressure.

The dolomite crystals most probably owe their origin to percolating water charged with salts of magnesia derived from the surrounding shales; and perhaps, in the case of the coral limestone, from the corals themselves, as a small quantity of magnesia is often present in the corallum.

Besides forming the intercalated beds of sandstone, silica is abundant in the limestones and clay-slates in the form of minute quartz-grains and crystals; and these would readily dissolve and re-crystallize during and after the processes of contortion and shearing, as is seen in the replacement and fringing of the oolitic grains.

It is interesting to note the close association of the oolitic granules in these beds with masses of the old reef-forming corals, an association similar to that found at the present time in tropical areas.

The patches of limestone in the shales undoubtedly owe their lenticular form to the forces which produced the shearing; but on account of the superior hardness of the limestone the surrounding shales have suffered more in being squeezed out of position, and have been altered into talc on the surfaces of the mass.

In concluding these notes it remains for me to express my obligations and thanks to Professor Judd, F.R.S., for his kind and valuable advice; to Professor Thorpe, F.R.S., for his kindness in supplying me with the analysis of the dolomitic limestone; and to my brother, Mr. R. S. Chapman, for his skill in producing the photographs from which the plate has been made.

EXPLANATION OF PLATE V.

Fig. 1.—Oolitic limestone of Devonian age, practically unaffected by pressure, from Sampson's Cave. × 14.

Fig. 1*a*.—The same rock treated with acid to show the siliceous portion. × 14.

Fig. 2.—Oolitic limestone with incipient cleavage, from Watermouth Cave. × 14.

Fig. 3.—Sheared and dolomitized oolitic limestone, from Rillage Point. × 14.

Fig. 4.—Extreme condition of sheared oolitic limestone, with "eyes" of calcite, and dolomite, from Rillage Point. × 14.

Fig. 4*a*.—A portion of the same more highly magnified, to show the dolomite crystals with their centres occupied by ferruginous material. × 36.

Fig. 5.—Sheared limestone formed of encrinite remains and oolitic grains; the ossicles and stem-joints of the encrinites are almost unaffected by the shearing forces. From Rillage Point. × 14.

Fig. 6.—Sheared coral limestone, from Watermouth. × 4.

III.—The Submergence of the British Isles during the Glacial Period.

By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

The question of the submergence of the British Isles during, at least, one stage of the Glacial period, is deserving of careful consideration by geologists. Until the visit of the late lamented Prof. Carvill Lewis to this country, no one, as far as I am aware, questioned the view that the British Isles have been submerged to a depth, in some places, amounting to 1300 or 1400 feet—this being the level at which shell-beds are found in some parts of England, Wales, and

Ireland. Prof. Lewis, however, struck out a new theory to account for the existence of these high-level shelly-gravels, which has since been adopted by Mr. Kendall[1] and other geologists, according to which these shell-beds have reached their present altitude by the agency of the great ice-sheet, which is credited with the astonishing power of having carried these deposits from the bed of the Irish Sea, and then of having laid them down in their final resting-place high up amongst the mountain groups of Wicklow, Wales, and Central England. It might be objected to this view, that, in the first place, the matter deposited at the tail of an ice-sheet is moraine matter, not usually stratified shelly gravel and clay; in the second, that in the process of transportation, such deposits, borne along for miles in the body, or at the foot, of the ice-sheet, and carried up the mountain slopes, would be ground into the finest mud or powder; and it seems inconceivable that even a few minute fragments of shells, sufficiently large for identification, should have survived such a destructive process; but this objection is considered invalid, so that we must have recourse to others.

Well then, thirdly, the view advocated supposes either that the ice-sheet in the Irish Sea attained an original thickness of 1300 or 1400 feet in the vicinity of the mountains aforesaid *plus* an additional thickness for the depth of the adjoining sea-bed, or else that it rose up from the sea-bottom and ascended the flanks and valleys of the mountains owing to the *vis a tergo*, or some other force of propulsion. The thickness of the ice-sheet in the latitude of Snowdon must have been over 1500 feet according to this calculation (a very improbable view as it seems to me); or the ice must have pushed the shell-beds several hundred feet up the Welsh and Wicklow slopes; a phenomenon which, as far as I am aware, has no example at the present day. In making this statement, I do not deny the power of glacier-ice to move over low opposing ridges, as in the case of Bray Head, but in such cases the whole of the opposing ridge has been enveloped in the mass of moving ice; and the conditions are very different from those which would occur where the ice-sheet is confronted by the flanks of still higher ridges.

But without insisting too strongly upon this objection I have another to advance which is absolutely fatal to the transportation theory of Prof. Carvill Lewis and his followers. In the case of North Wales, those who are acquainted with its glacial phenomena, or who have studied the writings of the late Sir A. C. Ramsay, are aware that there is no evidence whatever of an ice-movement inwards from the Irish Sea; but that, on the contrary, the ice-movements radiated outwards from the mountain heights. Ramsay, indeed, clearly describes what he calls "the Drift," and shows that it consists of Boulder-clay, sand, and gravel filling the bottoms and sides of the valleys up to a level of about 1300—1400 feet; but that this Drift is of marine origin, formed during a period of submergence, he has no doubt whatever. When describing it as rudely stratified, and containing blocks and boulders carried by floating icebergs, he says with reference to the question of submergence: "From circumstances presently to be mentioned, it is to me certain, that at a time when North Wales was so far submerged that only the higher mountain tops rose as islands, none of them more than about 2000 feet" above the surface, etc. (Old Glaciers of North Wales, p. 96). This is the deliberate opinion of one who, as Director of the Geological Survey, and as taking an active personal part in the work in North Wales for several years, had become familiar with every spot and section where the Glacial deposits were visible; and was investigating the phenomena of glaciation with the enthusiasm which their novelty at the time inspired. It is true that, as Ramsay himself determined, the ice-sheet of the Irish Channel was sufficiently thick to pass across Anglesea, and the low ground adjoining the Menai Straits in a S.W. direction; but there is no evidence whatever that it ascended the mountain slopes around Snowdon to a level of 1400—1500 feet above the present surface. It is in such Marine Drift deposits as those above described that the shells occur, not only at Moel-Tryfan, but in several other places, such as the valleys which descend from Carnedd Llewelyn, at elevations of about 1200—1300 feet and also in Denbighshire.

---

[1] Glacial Geology, Old and New. Geol. Mag. Dec. III. Vol. IX. p. 491.

Then as regards Ireland, the evidence is quite as conclusive. The shell-beds which were discovered by Mr. John Kelly, and the Rev. Maxwell Close, at Caldbeck Castle, at 1300 feet, and in several other localities, not so elevated, amongst the Wicklow Mountains, are by no means solitary representatives of submergence. They are detached portions of the shelly gravels of Wexford which reach levels of 300—400 feet, and of the great deposits of sand and gravel which cover such large tracts of the central plain of Ireland, up to levels of several hundred feet, and in which sea-shells have been found at various elevations, as in the Dargle Valley, at spots west of the Sugarloaf Mountain, and south of Enniskerry, county Wicklow, up to heights ranging from 500 or 600 up to 1000 or 1200 feet according to Jukes (Manual of Geology, 3rd edit. p. 709). They have also been found in more inland places. But the presence or absence of shells in these deposits is of very little consequence; the beds are the same, whether shells have been found in them or not; and it is easy to conceive how shells, originally contained, may have been dissolved out of them by percolating rain-water. That the shell-gravels of the central plain of Ireland are the same deposits as those which contain shells in the higher elevations, and that they are the result of submergence is the clear opinion of the late Prof. Jukes (*Ibid.* p. 710). If they had been formed by an ice-sheet, that ice-sheet must have moved *from the sea* and spread itself over the land-surface of Central Ireland, but this is exactly the reverse of the case, as shown by the glacial striæ and the *roches-moutonnées*. These have all been observed and tabulated in detail over the whole country by Mr. Close, the Geological Surveyors, and others, and will be found laid down on my map of the General Glaciation of Ireland (Phys. Geol. of Ireland, 2nd edit. p. 211), from which it will be seen that the movement of the great ice-sheet was everywhere *from the land* outward towards the present sea-coast. The direction of this movement, as determined by numerous observations is, I repeat, fatal to the transportation theory of Professor Carvill Lewis and his followers, which postulates a movement in an opposite direction. For myself I feel satisfied that the submergence view is the only one which meets the requirements of the case. I will only add a few words more in order to remove an erroneous impression to the effect that a submersion of 1300—1400 feet in the latitude of Snowdon and Wicklow involves a similar amount of depression to the north and south of that parallel. There is no such inference required. In the parallel referred to the depression (assuming the level of the ocean to have been constant) appears to have reached its maximum for the British Islands, gradually lessening northwards into Scotland, where, according to Prof. James Geikie, it was over 510 feet, marine shells being found in the Glacial series up to this level; in Norway they are found at 580 feet.[1] In an opposite direction beds of gravel, or scattered pebbles of quartz from the waste of the New Red Sandstone, are found up to a level of about 600 feet amongst the Cotteswold Hills on the borders of Oxfordshire and Gloucestershire.[2] No ice-sheet ever invaded this part of England, and the occurrence of these pebbles drifted from the north, and lying on the Jurassic table-land can be accounted for in no other way except by submergence. To the same series of Drift deposits are to be referred the "High-level gravels" of Oxfordshire, Wilts, Berks, Dorset, and the Isle of Wight—as also the "Middle Glacial Beds" of Messrs. S. V. Wood and J. L. Rome in the Eastern Counties, reaching elevations of about 200—300 feet. All the phenomena point to an inter-Glacial epoch of deep submergence, and the conversion of the British Isles into an Archipelago of small islets washed by cold water, and sometimes encumbered with ice of local origin.

IV.—The True Horizon of the Mammoth.

By Mark Stirrup, F.G.S.

In some recent articles contributed to the Geological Magazine, Sir Henry H. Howorth has sought to establish by a great array of authorities, both British and foreign, the pre-Glacial, or at least pre-Boulder Clay, age of the Mammoth.

As Sir Henry claims to have proved his case—a proposition which probably few geologists will admit—and "calls upon those who still maintain a post-Glacial or inter-Glacial existence of the Mammoth to prove their case," I will attempt, to offer some little evidence to show that the conclusion he has arrived at is scarcely warranted by the facts.

In order not to unduly trespass on the limited space, I do not intend to analyze the value of the British evidence which Sir Henry has adduced, as that has been already criticised by Mr. A. J. Jukes-Browne, but propose to confine myself simply to the consideration of the foreign evidence.

---

[1] In the Lake District the late Mr. Clifton Ward has traced stratified gravels up to a level of at least 1500 to 1600 feet.—"Geology of the Northern part of the Lake District," Mem. Geol. Survey, p. 94.

[2] Quart. Journ. Geol. Soc. vol. xi. p. 477.

In doing so, I shall endeavour to follow as nearly as possible the path which Sir Henry has traced, and shall rely for rebutting evidence on some of the authorities he has himself quoted. His survey commences with Switzerland, and amongst other quotations, he cites somewhat at length the famous lignite beds at Dürnten and Utznach. The unsatisfactory character of much that has been written on these deposits he seems to feel, and certainly the record of the animal remains found in them will not strengthen the position he has taken up, for if they prove anything at all in support of his thesis, they prove far too much. The beds are acknowledged to be much disturbed in places, and yield not only the bones of the Mammoth and the Woolly Rhinoceros, together with the Pliocene beasts *E. antiquus* and *R. leptorhinus*; but animals of a later type, such as the cave-bear, the urus (*Bos primigenius*) and Elk, and also of existing species, as for instance the Red Deer, *Cervus elaphus* (see Heer's Primæval Switzerland and Prof. Rütimeyer).

If Sir Henry Howorth claims the Mammoth for a pre-Boulder Clay animal, he will scarcely be bold enough to claim all its associates in these lignite beds as of a like age.

Turning now to the authority of M. Favre, who is cited as "saying distinctly that the Glacial beds with their erratics, which are greatly developed in the neighbourhood of Geneva, are superimposed on the so-called 'alluvion ancienne,' *i.e.* the stratum in which the Pleistocene animals occur."

The phrase, "alluvion ancienne," as used by Swiss geologists, has not a fixed application, as will be seen from the following extract taken from Prof. Favre's "Recherches Géologiques dans les parties de la Savoie," vol. i. p. 32, in which he describes the Terrace Alluviums in the neighbourhood of Geneva as belonging to the prehistoric age, but which are perhaps contemporary with Man.

M. Favre goes on to say "that some authors call them 'alluvions anciennes,' and others *post-glacial* alluviums. They never contain striated stones nor erratic blocks. They are *superimposed* on Glacial beds, etc." (the italics are mine).

But further, Prof. Favre expresses himself explicitly on the point under discussion as to the true horizon of the Mammoth (*op. cit.* p. 50): "The remains of *Elephas primigenius* found in our country are valuable in that they fix in a very positive manner the age of that animal—they come from the *post-Glacial* beds."

Again, on page 52, M. Favre says, "In the interior of the Jura, bones of *E. primigenius* have been found at Tenay upon the railway line from Lyons to Geneva, and on the other side of the chain, near Poligny, remains of this animal have been gathered in the sands and gravels *above* the Glacial beds with polished and striated stones. It is still in the post-Glacial alluviums that the bones of *Elephas primigenius* have been met with near Tullins in Dauphiny. It is then evident that if the *E. primigenius* lived during the Glacial epoch, a fact which does not appear to me yet sufficiently proved, it has equally inhabited our country during the formation of the terrace alluviums." From the above extracts it will be seen that Prof. Favre's opinions afford no support to Sir Henry Howorth's contention.

M. Falsan, another authority quoted by Sir Henry, but apparently only on the question of inter-Glacial periods, classifies, in his Synoptical Table (*vide* La Période Glaciaire) of the Pliocene and Quaternary Beds of the Environs of Lyons, *E. primigenius* as post-Glacial, and occurring in the Lehm, uniformly spread over the ancient or Glacial alluviums.

In the valley of the Rhine it is also in the superficial loamy deposits called Lehm or Loess, which certainly belong to the closing phases of the Ice-Age, that we find the most abundant remains of the Mammoth and its contemporaries; moreover, the cavern deposits of both England and the Continent afford ample evidence of the co-existence of Man and the Mammoth.

In America, Sir Henry Howorth says the evidence seems to be very contradictory. It is truly a stumbling block to the acceptance of his conclusions. The remains of the Mammoth and Mastodon are well known to occur there in the most superficial deposits. Prof. Shaler says: "Almost any swampy bit of ground in Ohio or Kentucky contains traces of these animals; and at Big Bone Lick the remains are so well preserved as to seem not much more ancient than the Buffalo bones which are found above them."

Indeed, the evidence of the true Mammoth having existed in America, long after the period of the Northern Drift, seems so conclusive, and is so well known to geologists, as to be almost beyond question.

In bringing these criticisms to a conclusion, with that of the Russian evidence, on which Sir Henry, relying on the opinion of his "old masters" has always laid great stress, I propose, instead of resorting to ancient history, to bring forward the published researches of living and recent explorers for the refutation of my friend's postulate.

For the first example I quote the stratigraphical and palæontological testimony afforded by the recent investigations of M. Tchernyschew quite at the north of Russia in Europe, in the Timan district of the Province of Archangel (*vide* Bull. Com. Géol. St. Pétersbourg, Tome x. p. 95–147). This explorer says: "All around the Timan chain extend immense plains occupied by mosses and marshes—region of Tundra. Striated pebbles abound everywhere, the quaternary glacial sea formed a vast gulf which extended as far as the line of the rivers Tzylma—Volonga. *Above* and transgressively on these deposits, sands and gravels are met with containing bones of *Elephas primigenius* and *Rangifer tarandus*."

Stronger evidence still, but of like character, comes from that so-called "home of the Mammoth"—North-East Siberia—where those vast accumulations of the bones of the Mammoth occur, which have always excited the greatest wonder and perplexity.

A Russian scientific expedition, under the auspices of the Academy of Sciences of St. Petersburg, has recently returned from the exploration of the New Siberian Islands and the mainland opposite, the Yana district, between the rivers Lena and Indigirka.

The scientific results of the expedition are in the course of being classified and published in the Memoirs of the Academy. Two of these Memoirs have already appeared, and a third has just been finished, bearing the title "The Bed of Fossil Ice in its Relation to the Deposits of Mammoth Carcases," by Baron de Toll.

I have not yet seen this last Memoir, but am indebted for my knowledge of its contents to the remarks and analysis of M. Schmidt when calling attention to the work at the meeting of the Academy on the 27th January, 1892.

It has been long known that in North Siberia, as well as in certain regions of North America, ice is met with in the ground under the form of a rock. To this ice several names have been given by different authors, and Baron de Toll proposes a new name, that of ice-rock (Steineis) or fossil ice. Of this he distinguishes three types: (1) that filling fissures in the ground; (2) the beds of ice in the valleys; (3) that of the continuous horizontal beds, very frequent in the New Siberian Islands, and upon the mainland opposite.

Upon this ice is *superposed* the recent argillaceous beds containing the bones of quaternary animals, and even their entire carcases.

Baron de Toll explains in the following way the finding of Mammoth bones and carcases in or upon this palæocrystic ice, in which, he says, they were *never* originally enclosed. In Spring, the waters scour in part these upper beds of clay, and the bones as well as the carcases fall to the bottom; it is thus that they are then found, quite at the bottom of the series of these beds.

The remains of a Mammoth found by M. de Toll in the Valley of Bar-Ourikh, to east of the town of Oust-Yansk, were found in the argillaceous beds which covered some thick beds of the valley ice. In the large island of Linkhof, one of the New Siberian group, he was shown the place where the carcase of a Mammoth had been found in a great cleft which had affected the upper stratum of clay as well as the upper layer of ice; the carcase had fallen to the bottom and was thus preserved in the ice. Analyzing in detail all the information relating to the famous Mammoth carcase brought by Mr. Adams (1806) to St. Petersburg from the mouth of the Lena, Baron de Toll arrives at the conclusion that this carcase had likewise fallen from above to the bottom of a crack in the ice, and was consequently found "in the middle of blocks of ice," according to Mr. Adams' expression.

This explanation gains support from the explorations of Dr. Dall, in Alaska (quoted by Prof. Wright, "Ice Age in North America," pp. 33–35), where the conditions are much the same as in Siberia, and where large numbers of the bones of the Mammoth also occur, and which are often found at the foot of the ice-cliffs in Eschscholtz Bay. Dr. Dall, after speaking of the vegetation of the tundra and its luxuriant growth of herbage, adds: "The formation of the surrounding country shows no high land or rocky hills from which a glacier might have been derived and then covered with *débris* from their sides. The continuity of the mossy surface showed that the ice must be quite destitute of motion, and the circumstances appeared to point to one conclusion, that there is here a ridge of solid ice rising several hundred feet above the sea and higher than any of the land about it and *older* (italics mine) than the Mammoth and fossil horse, this ice taking upon itself the functions of a regular stratified rock."

It appears to me that this recent evidence shakes to its foundation that memorable phrase of Cuvier (Discours sur les Révolutions de la Surface du Globe), based on the assumed proof of Adams's Mammoth having been frozen up in the solid ice where found, suddenly and without warning. "Cette gelèe éternelle n'occupait pas auparavant les lieux où (les Mammouths) ils ont été saisis; car ils n'auraient pas pu vivre sous une pareille température. C'est donc le même instant qui a fait périr les animaux, et qui a rendu glacial le pays qu'ils habitaient. Cet événement a été subit, instantané, sans aucune gradation," etc.

If Sir Henry Howorth is able to prove his postulate of the pre-Glacial or pre-Boulder Clay advent of the Mammoth, there is, undoubtedly, I think, unimpeachable testimony of its existence long after the great cold, and up to the close of the Quaternary period, which would thus justify the application of Geoffroy Saint Hilaire's name of *Dicyclotherium* to the Mammoth, as the beast that had lived through two epochs.

V.—Additions to the Type Fossils in the Woodwardian Museum.

By Henry Woods, B.A., F.G.S.

In the "Catalogue of Type Fossils in the Woodwardian Museum, Cambridge," an account was given of all the types and described specimens known to be in the Museum at the end of November, 1891. The work is here continued to December 31st, 1892. The additions given consist of (1) Types presented during the year 1892; (2) Specimens described during the year; (3) Specimens which were in the Museum at the time of publication of the Catalogue but which were not then known to be types.

The authors who have described these specimens are, the late Prof. L. Agassiz, Mr. F. A. Bather, the late Dr. T. Davidson, the late Mr. E. W. Binney, the Rev. J. F. Blake, Mr. W. H. Hudleston, Prof. T. Rupert Jones, Prof. C. Lapworth, the late Count Münster, Dr. R. H. Traquair, the Rev. G. F. Whidborne, and Dr. H. Woodward.

To the list of collections in the Museum given on pages xiii and xiv of the Catalogue the following should be added:—

Binney Collection.—Carboniferous Plants, Old Red Sandstone Fishes, and various other fossils, collected by the late Mr. E. W. Binney, F.R.S., and presented by his son Mr. James Binney, B.A., in 1892.

The collection contains plants and fishes figured and described by Mr. Binney.

Carter Collection.—Portions of the collection of Mr. James Carter, F.R.C.S., presented at various times, and consisting chiefly of fossils from the Jurassic and Cretaceous formations of the neighbourhood of Cambridge, including several types.

Tawney Collection.—The collection of the late Mr. E. B. Tawney, M.A., consisting of fossils from various formations, the most important being from the Carboniferous Limestone of the neighbourhood of Bristol.

In the list which follows, as in the Catalogue itself, the only references given are those which relate to the actual specimens in the Museum. The types are distinguished by the letter [T].

PLANTÆ.

CALAMODENDRON COMMUNE, E. W. Binney, Obs. Struct. Foss. Plants. Carb. part i. (1868), pl. iv. f. 2, p. 24. *Coal Measures* (*Upper Brooksbottom Seam*); *Lancashire.* Binney Collection. [T.]

HALONIA REGULARIS, Lindley and Hutton, E. W. Binney, Obs. Struct. Foss. Plants Carb. part iii. (1872), pl. xv. f. 1–4, p. 89. *Coal Measures*; *near Dudley.* Binney Collection.

Binney, *ibid.* (1872), pl. xvi. f. 2–5, p. 90. *Coal Measures* (*Upper Brooksbottom Seam*); *Lancashire.* Binney Collection.

LEPIDODENDRON HARCOURTI, Witham, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. vii. f. 3–5, p. 46. *Coal Measures* (*Upper Foot Seam*); *near Oldham.* Binney Collection.

Binney, *ibid.* part iii. (1872), pl. xiii. f. 1, 3, p. 77. *Coal Measures*; *near Dudley.* Binney Collection.

LEPIDODENDRON VASCULARE, E. W. Binney, Quart. Journ. Geol. Soc. vol. xviii. (1862), pl. vi. f. 2–5, p. 106. *Coal Measures*; *Lancashire.* Binney Coll. [T.]

Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. viii. f. 3, p. 49. *Coal Measures* (*Upper Foot Coal*); *near Oldham.* Binney Collection.

LEPIDOSTROBUS ? DUBIUS, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. ix. f. 3, p. 52. *Carboniferous* (*Blackband Ironstone*); *near Airdrie.* Binney Collection. [T.]

LEPIDOSTROBUS HIBBERTIANUS, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. x. f. 2, 2*a*, *b*, p. 55. *Lower Carboniferous* (*Burdiehouse Limestone*); *near Edinburgh.* Binney Collection. [T.]

LEPIDOSTROBUS RUSSELLIANUS, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. ix. f. 2, 2*a*, p. 51. *Carboniferous* (*Blackband Ironstone*); *near Airdrie.* Binney Collection. [T.]

SIGILLARIA VASCULARIS, E. W. Binney, Quart. Journ. Geol. Soc. vol. xviii. (1862), pl. iv. f. 2, 4, 5, pl. v. f. 2–4, p. 106. *Coal Measures*; *Lancashire.* Binney Collection. [T.]

E. W. Binney, Obs. Struct. Foss. Plant Carb. part iii. (1872), pl. xiv. f. 4–6, p. 81. *Coal Measures* (*Bullion Seam*); *Spa Clough, near Burnley.* Binney Coll.

Binney, *ibid.* part iv. (1875), pl. xix. f. 1, pl. xx. f. 1, p. 136. *Coal Measures* (*Hard Seam*); *South Owram, Yorks.* Binney Collection.

Binney, *ibid.* part iv. (1875), pl. xxiii. f. 1, p. 141. *Coal Measures* (*Bullion Seam*); *Clough Head, near Burnley.* Binney Collection.

CRINOIDEA.

CYATHOCRINUS ACINOTUBUS, Angelin, F. A. Bather, Ann. Mag. Nat. Hist. ser. 6, vol. ix. (1892), pl. xiii. f. 3–5, p. 213. *Wenlock Limestone*; *Dudley.* Fletcher Collection.

MASTIGOCRINUS LOREUS, F. A. Bather, Ann. Mag. Nat. Hist. ser. 6, vol. ix. (1892), pl. xi. f. 3, pp. 194–202. *Wenlock Limestone*; *Dudley.* Fletcher Collection. [Specimen referred to in Catalogue as *Cyathocrinus arboreus*, Salter.] [T.]

BRACHIOPODA.

Discina annulosa, T. Davidson, Brit. Foss. Brach. vol. iv. (1876), pl. x. f. 15, 15*a*, *b*, p. 87. *Cornbrash*; *Scarborough*. Leckenby Collection. [T.]

Rhynchonella speetonensis, Davidson. The specimen referred to on page 60 of Catalogue is probably in the Leckenby Collection.

Terebratula depressa, Lamarck, T. Davidson, Brit. Foss. Brach. vol. iv. (1874), pl. iv. f. 2, p. 40. *Lower Greensand*; *Upware*.

LAMELLIBRANCHIATA.

Actinopteria crenatissima (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ix. f. 9, 9*a*, p. 77. *Pterinea crenatissima*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Actinopteria dilatata (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vi. f. 9, 9*a*, 10, pl. vii. f. 1, 1*a*, 3, p. 64. *Pterinea dilatata*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Actinopteria hirundella (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vii. f. 4, 4*a*, *b*, p. 61. *Aviculopecten hirundella*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Actinopteria justi (Freck), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vii. f. 12, 12*a*, p. 70. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

Actinopteria placida (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vii. f. 5, 5*a*, 9, 10, 10*a*, 11, 11*a*, p. 67. *Pterinea placida* and *P. obovata*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Actinopteria? robertsi, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vi. f. 2, 2*a*, 3, 3*a*, 4, p. 60. *Middle Devonian*; *Lummaton*. Figs. 2 and 3 presented by the Rev. G. F. Whidborne, M.A. [T.]

Actinopteria rudis (Phillips), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. viii. f. 4, 6, 6*a*, p. 73. *Pterinea rudis*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889) p. 78. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

Actinopteria wurmi (Römer), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. viii. f. 2, 3, 5, p. 71. *Pterinea wurmi*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 78. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

Allorisma dubium (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 3, p. 4. *Edmondia ? dubia*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Aviculopecten aviformis, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 79, and Devonian Fauna S. Eng. vol. ii. (1892), pl. x. f. 7, 7*a*, 8, 8*a*, p. 85. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Aviculopecten comma, v. Crenipecten ? comma.
——— *consolans*, v. Pterinopecten consolans.
——— *cybele*, v. Pterinopecten cybele.
——— *gracilinus*, v. Pterinopecten gracilinus.
——— *hirundella*, v. Actinopteria hirundella.

Conocardium clathratum, d'Orbigny, G. F. Whidborne, Devonian Fauna, S. Eng. vol. ii. (1892), pl. i. f. 17, 17*a*, 18, 18*a*, 19, 19*a*, *b*, *c*, p. 18. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

Conocardium frater, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ii. f. 10, 10*a*, p. 30. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Conocardium pugnans (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ii. f. 4, 4*a–c*, 5, 5*a*, p. 24. *Pleurorhynchus pugnans*, G. F. Whidborne, Geol. Mag. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

CONOCARDIUM VILLMARENSE (d'Archiac and de Verneuil), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ii. f. 8, 8*a–c*, 9, p. 28. *Pleurorhynchus villmarensis*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A.

CRENIPECTEN? COMMA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. x. f. 4, 4*a*, 5, 5*a*, p. 88. *Aviculopecten comma*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A. [T.]

Cypricardia ensiformis, v. Cypricardinia ensiformis.

——— *guttata*, v. Cypricardinia reticulata.

——— *neglecta*, v. Cypricardinia scalaris.

CYPRICARDINIA ENSIFORMIS (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 15, p. 13. *Cypricardia ensiformis*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A. [T.]

CYPRICARDINIA RETICULATA (Phillips), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 11, 11*a*, p. 11. *Cypricardia guttata*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A. [*C. guttata*, T.]

CYPRICARDINIA SCALARIS (Phillips), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 7, 8, p. 5. *Cypricardia neglecta*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A.

Edmondia? dubia, v. Allorisma dubium.

GOSSELETIA? sp., G. F. Whidborne. Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 6, 6*a*, p. 50. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A.

HOPLOMYTILUS CRASSUS, Sandberger, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 78, and Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 3, 3*a*, p. 44. *Middle Devonian*; *Wolborough.*

Myalina elliptica. v. Rutotia elliptica.

MYALINA LUNA, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 1, p. 48. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A. [T.]

NUCULA PROTEI, Münster, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iii. f. 3, 3*a*, p. 37. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A.

PLETHOMYTILUS RETORTUS, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. v. f. 1, p. 52. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A. [T.]

Pleurorhynchus pugnans, v. Conocardium pugnans.

——— *villmarensis*, v. Conocardium villmarense.

PROTOSCHIZODUS? TRIGONELLUS, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iii. f. 2, p. 36. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A. [T.]

Pterinea crenatissima, v. Actinopteria crenatissima.

——— *dilatata*, v. Actinopteria dilatata.

——— *placida*, v. Actinopteria placida.

——— *obovata*, v. Actinopteria placida.

——— *rudis*, v. Actinopteria rudis.

——— *wurmi*, v. Actinopteria wurmi.

PTERINOPECTEN CONSOLANS (Barrande), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ix. f. 11, p. 83. *Aviculopecten consolans*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 78. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A.

PTERINOPECTEN CYBELE (Barrande), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. viii. f. 9, 9*a*, 10, 10*a*, p. 82. *Aviculopecten cybele*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 78. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A.

PTERINOPECTEN GRACILINUS (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ix. f. 10, p. 80. *Aviculopecten gracilinus*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Wolborough.* Presented by the Rev. G. F. Whidborne, M.A. [T.]

RUTOTIA ELLIPTICA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 9, 9*a*, 10; pl. v. f. 2, 2*a*, 4, 4*a*, 6, 7, 8, 8*a*, p. 55. *Myalina elliptica*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

GASTEROPODA.

BELLEROPHON HICKSI, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxxi. f. 7, 7*a*, *b*, p. 326. *Middle Devonian*; *Wolborough*. Presented by G. M. Hicks, Esq. [T.]

BELLEROPHON LINEATUS [Goldfuss, MS.], de Ferussac and d'Orbigny, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxxi. f. 3, 3*a*, *b*, p. 321. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

DIRHACHIS ATAVUS, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1891), pl. xxv. f. 15, p. 157. *Middle Devonian*: *Chudleigh*. [T.]

DISCOHELIX SPINOSUS [Wright, MS.], W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xxv. f. 8, p. 317. *Inferior Oolite* (*Concavus-bed*); *Bradford Abbas*. [T.]

EUOMPHALUS ? ARANEIFER, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxiv. f. 13, p. 253. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

EUOMPHALUS FENESTRALIS, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxv. f. 2, p. 254. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

EUOMPHALUS GERMANUS (Phillips), G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxv. f. 5, 5*a*, *b*, p. 256. *Middle Devonian*; *Wolborough*.

Euomphalus serpula, v. Phanerotinus militaris.

LITTORINA UNICARINATA [Bean, MS.], W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xxiii. f. 1, p. 289. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 105.] [T.]

MACROCHILINA SUBCOSTATA (Schlotheim), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1891), pl. xvi. f. 2, 2*a*, p. 159. *Macrocheilus subcostatus*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

MURCHISONIA MARGARITA, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxx. f. 20, 20*a*, p. 318. *Middle Devonian*; *Chudleigh*. [T.]

MURCHISONIA TURBINATA (Schlotheim), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxix. f. 8, 15; pl. xxx. f. 1, 2, 4, p. 306. *Middle Devonian*; *Chudleigh*. Presented by the Rev. G. F. Whidborne, M.A.

NATICA DUNDRIENSIS (Tawney), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 11*b*, *c*, p. 262. *Inferior Oolite*; *Dundry*.

NATICA LORIERI, d'Orbigny, var. CANINA, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 9*a*, p. 260. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 108, as *Natica adducta*, Phillips, var. *canina*.] [var. canina T.]

NATICA LORIERI, d'Orbigny, var. PROXIMA, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 7, p. 260. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 108, as N. proxima.] [var. proxima, T.]

NATICA PUNCTURA (Bean) (? bajocensis, d'Orbigny), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 14, p. 264. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 109.]

PHANEROTINUS MILITARIS, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxv. f. 11, p. 259. *Euomphalus serpula*, de Koninck, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

PLEUROTOMARIA BISCHOFFI, Goldfuss, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxxi. f. 1, 1*a*, p. 305. *Middle Devonian*; *Lummaton*. Tawney Collection.

PLEUROTOMARIA CHUDLEIGHENSIS, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxviii. f. 2, p. 292. *Middle Devonian*; *Chudleigh*. [T.]

PLEUROTOMARIA SUBIMBRICATA, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxviii. f. 6, p. 293. *Middle Devonian*; *Lummaton.* Tawney Collection. [T.]

Another specimen, Whidborne, *ibid.* pl. xxviii. f. 7, p. 293. *Pleurotomaria imbricata*, F. McCoy (*non* Römer), Brit. Palæoz. Foss. (1885), p. 393. *Middle Devonian*; *Wolborough.* [T.]

PLEUROTOMARIA VICTRIX, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxviii. f. 15, 16, p. 301. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A. [T.]

PSEUDOMELANIA PROCERA (Deslongchamps), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xviii. f. 2, p. 237. *Dogger Series*; *Blue Wyke.* Leckenby Collection. [Specimen referred to in Catalogue, p. 101, as *Chemnitzia lineata* (Sowerby).]

PSEUDOMELANIA SCARBURGENSIS ? (Morris and Lycett), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xix. f. 3, p. 243. *Scarborough Limestone*; *Scarborough.* Leckenby Collection. [Specimen referred to in Catalogue, p. 101, as *Chemnitzia lineata-procera*, var. *scarburgensis*, Morris and Lycett.]

ROTELLINA ? HELICINA (Münster), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxvi. f. 10, 10*a*, p. 269. *Middle Devonian*; *Lummaton.* Tawney Collection.

SOLARIUM SUBVARICOSUM, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xxvi. f. 12, p. 324. *Inferior Oolite*; *Yeovil.* Walton Collection. [T.]

STRAPAROLLUS EXSERTUS, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xxvi. f. 4, p. 320. *Inferior Oolite*; *probably from Stoford.* [T.]

POLYPLACOPHORA.

? HELMINTHOCHITON PAPILIO (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1891), pl. xxxi. f. 16, p. 334. *Chiton papilio*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30. *Middle Devonian*; *Lummaton.* Presented by the Rev. G. F. Whidborne, M.A.

CEPHALOPODA.

ÆGOCERAS DIVERSUM (Simpson), J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. viii. f. 3, p. 282. *Lias* (*probably capricornus-zone*); *Whitby.* Leckenby Collection.

ÆGOCERAS ? FINITIMUM [Bean, MS.], J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. vi. f. 9, p. 273. *Lower Lias* (? *bucklandi-zone*); *Robin Hood's Bay.* Leckenby Collection. [T.]

ÆGOCERAS SAGITTARIUM, J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. vii. f. 2*a*, *b*, p. 276. *Lias* (*jamesoni*) *zone*; *Robin Hood's Bay.* Leckenby Collection. [Specimen referred to in Catalogue, p. 121, as *Ammonites* (*Ægoceras*) *acuticostatum.*] [T.]

ÆGOCERAS SOCIALE (Simpson), J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias 1876), pl. vii. f. 6, p. 278. *Lias* (*armatus-zone*); *Robin Hood's Bay.* Leckenby Collection.

ÆGOCERAS VALIDUM (Simpson), J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. vii. f. 3, p. 278. *Middle Lias*; *Robin Hood's Bay.* Leckenby Collection.

TRILOBITA.

OLENELLUS CALLAVEI, C. Lapworth, GEOL. MAG. Dec. III. Vol. V. (1888), p. 485, and "Nature," vol. xxxix. (1888) p. 213, and GEOL. MAG. Dec. III. Vol. VIII. (1891), pl. xiv. f. 1–17, 21–23, p. 530. *Comley Sandstone*; *Comley Quarry.* [T.]

PHYLLOCARIDA.

APTYCHOPSIS ANGULATA ? (Baily), T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xv. f. 17, p. 111. *Brathay Flags*; *Nanny Lane, Troutbeck.* Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 134, as *Aptychopsis* sp.]

Aptychopsis cordiformis, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xv. f. 2, p. 103. *Lower Wenlock*; *Rebecca Hill, Ulverston.* [Specimen referred to in Catalogue, p. 133.] This specimen is the type of *Peltocaris anatina*, Salter. [T.]

Aptychopsis lapworthi, Woodward, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xv. f. 3, p. 107. *Skelgill Beds*; *Skelgill.* Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 133.]

Caryocaris marri, Hicks, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 18, p. 92. *Upper Arenig*; *Nantlle Tramway.* Presented by J. E. Marr, Esq. [Specimen referred to in Catalogue, p. 134.] [T.]

Caryocaris wrighti, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 15, p. 90. *Skiddaw Slates*; *Cumberland.*

Caryocaris? sp., T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvii. f. 9–11, p. 124. *Upper Arenig*; *Nantlle Tramway.* Presented by J. E. Marr, Esq., F.R.S.

Ceratiocaris? sp., T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvii. f. 12, p. 124. *Skelgill Beds*; *Skelgill.* Presented by J. E. Marr, Esq., F.R.S.

Discinocaris browniana, Woodward, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvi. f. 17–19, p. 119. *Skelgill Beds*; *Lower Footbridge, Skelgill.* Presented by J. E. Marr, Esq., F.R.S.

Discinocaris gigas, Woodward, T. R. Jones and H. Woodward, Geol. Mag. Dec. III. Vol. I. (1884), p. 351, and Rep. Brit. Assoc. 1884 (1885), p. 80, and Brit. Palæoz. Phyllop. (1892), pl. xvii. f. 2, p. 122. *Skelgill Beds*; *Skelgill Beck.* Presented by J. E. Marr, Esq., F.R.S.

Hymenocaris? lata, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), p. 80, woodcut 4. *Upper Tremadoc*; *Garth, Portmadoc.* [Specimen referred to in Catalogue, p. 134, as *Ceratiocaris? lata.*] [T.]

Hymenocaris vermicauda, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiii. f. 1, 4, 5, 6, pp. 74–78. *Middle Lingula Flags*; *Borth, Portmadoc.* [Specimen referred to in Catalogue, p. 136.]
Another specimen, Jones and Woodward, *ibid.* (1892), pl. xiii. f. 12, p. 77. *Lingula Flags*; *Wern.*
Another specimen, Jones and Woodward, Rep. Brit. Assoc. 1883 (1884), p. 221, and Brit. Palæoz. Phyllop. (1892), pl. xiii. f. 7, p. 79. *Lingula Flags*; *Caen-y-Coed, Maentwrog.*

Lingulocaris lingulæcomes, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), p. 81. *Lingula Flags*; *Garth, Portmadoc.* [Specimen referred to in Catalogue, p. 136.] [T.]

Lingulocaris salteriana, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), p. 83. *Lower Lingula Flags*; *Caen-y-Coed, near Maentwrog.*
Another specimen, Jones and Woodward, *ibid.* (1892), p. 83. *Brathay Flags*; *E. side of Long Sleddale.* [Specimens referred to in Catalogue, p. 136.]

Peltocaris anatina, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvi. f. 5, p. 115. *Skelgill Beds*; *W. side of Long Sleddale.* Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 136.]

Peltocaris patula, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvi. f. 11, p. 116. *Skelgill Beds*; *Skelgill.* Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 136, as *Peltocaris* sp.] [T.]

Saccocaris major (Salter), T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 6, p. 84. *Lower Lingula Flags*; *Caen-y-Coed, near Maentwrog.* Presented by D. Homfray, Esq. [Specimen referred to in Catalogue, p. 136.]

Saccocaris minor, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 7–9, p. 86. *Arenig Beds*; *Craig-yr-hyrddod, Arenig.* Presented by Professor Hughes. [Specimens referred to in Catalogue, p. 137.] [T.]
Another specimen (?), Jones and Woodward, *ibid.* (1892), pl. xiv. f. 10, p. 88. *Lingula Flags*; *Wern, Portmadoc.*

DECAPODA.

ÆGER LONGIROSTRIS, G. G. Münster, Petrefactenkunde (1839), pl. xxvi. p. 67. *Lithographic Slate*; *Eichstädt*. Münster Collection. [T.]

ALVIS OCTOPUS, G. G. Münster, Petrefactenkunde, heft. iii. (1840), pl. i. f. 1, p. 20. *Lithographic Slate*; *Eichstädt*. Münster Collection. [T.]

BOLINA ANGUSTA, G. G. Münster, Petrefactenkunde (1839), pl. ix. f. 14, p. 24. *Lithographic Slate*; *Solenhofen*. Münster Collection. [T.]

ERYON LATUS, G. G. Münster, Petrefactenkunde (1839), pl. v. f. 6, p. 9. *Lithographic Slate*; *Eichstädt*. Münster Collection. [T.]

ERYON MEYERI, G. G. Münster, Petrefactenkunde (1839), pl. iii. f. 1, p. 6. *Lithographic Slate*; *Solenhofen*. Münster Collection. [T.]

ERYON OVATUS, G. G. Münster, Petrefactenkunde (1839), pl. vii. f. 3, p. 12. *Lithographic Slate*; *Solenhofen*. Münster Collection (counterpart). [T.]

ERYON SCHUBERTI (Meyer), G. G. Münster, Petrefactenkunde (1839), pl. vii. f. 9, p. 13. *Lithographic Slate*; *Solenhofen*. Münster Collection (counterpart.)

ERYON SUBPENTAGONUS, G G. Münster, Petrefactenkunde (1839), pl. vi. f. 2, p. 10. *Lithographic Slate*; *Kelheim*. Münster Collection. [T.]

GLYPHÆA ELONGATA, G. G. Münster, Petrefactenkunde (1839), pl. viii. f. 9, p. 18. *Lithographic Slate*: *Solenhofen*. Münster Collection. [T.]

GLYPHÆA LÆVIGATA, G. G. Münster, Petrefactenkunde (1839), pl. ix. f. 5, p. 20. *Lithographic Slate*; *Solenhofen*. Münster Collection. [T.]

MEGACHIRUS BAJERI (Bronn), G. G. Münster, Petrefactenkunde (1839), pl. xiii. f. 7, p. 33. *Lithographic Slate*; *Solenhofen*. Münster Collection.

PALINURINA INTERMEDIA, G. G. Münster, Petrefactenkunde (1839), pl. xiv. f. 9, p. 37. *Lithographic Slate*; *Solenhofen*. Münster Collection. [T.]

PISCES.

ELONICHTHYS BINNEYI, R. H. Traquair, GEOL. MAG. Dec. III. Vol. V. (1888), p. 251. *Lower Coal Measures*; *Stanton, Derbyshire*. Binney Collection. [T.]

GYRODUS GRACILIS, G. G. Münster, Petrefactenkunde, heft. iii. (1840), pl. viii. f. 2*a*, *b*, p. 128. *Lithographic Slate*; *Kelheim*. Münster Collection. [T.]

GYRODUS RUGOSUS [Münster MS.], L. Agassiz, Poiss. Foss. vol. ii. (1839), pl. lxix. f. 1–4, p. 227. *Lithographic Slate*; *Kelheim*. Münster Collection. [T.]

HOLOPTYCHIUS SAUROIDES, Williamson, E. W. Binney, Trans. Manchester Geol. Soc. vol. i. (1841), pl. v. f. 8, 10, p. 165. *Coal Measures*; *Pendleton*. Binney Collection.

MEGALICHTHYS HIBBERTI, Agassiz, E. W. Binney, Trans. Manchester Geol. Soc. vol. i. (1841), pl. v. f. 4, p. 162. *Coal Measures*; *Pendleton*. Binney Collection.

MESOLEPIS MICROPTERUS, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. (1879), p. 356. *Lower Coal Measures* (*Dalemoor Rake Ironstone*); *Stanton-by-Dale, Derbyshire*. Binney Collection. [T.]

PALÆONISCUS EGERTONI [Agassiz, MS.] (Egerton), E. W. Binney, Trans. Manchester Geol. Soc. vol. i. (1841), pl. v. f. 12, p. 166. *Coal Measures*; *Pendleton*. Binney Collection.

NOTICES OF MEMOIRS.

I.—THE MOUNTAINS OF SCOTLAND. By MARCEL BERTRAND, Professor in the École des Mines, Paris. Translated by G. A. LEBOUR, M.A., Professor of Geology in the Durham College of Science, Newcastle. From the "Revue générale des Sciences pures et appliquées," No. 23, December 15, 1892.

THE chief impression carried away by all visitors to Scotland is that Scotland is a country of mountains. Notwithstanding the somewhat low altitude of the heights (the tallest peak, Ben Nevis, does not reach 1400 metres), one could at many points imagine oneself in the upland valleys or on the higher plateaux of the Alps.

Latitude has something to do with this. As is the case with the flora, with which its aspects are associated, so there is in the scenery a northern character which in many ways reminds one of the Alpine character. The impression produced corresponds no less with a geological truth: Scotland is one of the countries in which are to be found the best marked traces of those great movements of the earth's crust by which mountains have been created. It is the witness of an ancient chain which ran on into Norway, of which the central core must have been located in the Grampian *massif*, and of which the slightly diverging subordinate ranges were directed to the north-east, towards Edinburgh, and nearly to the north along the western coast, facing the Hebrides. This chain is doubly interesting, first because of its size and of the complex accidents which the work of the last ten years has made known within it, and also because of its great antiquity: the *Caledonian Chain* is one of the oldest, if not the oldest, which it is given us to reconstruct. One finds oneself there face to face with movements dating from the dawn of primary times, that is, from a time when theoretically[1] the mean thickness of the crust affected by these movements must have been sensibly less than at the time of the formation of the Alps. Was there in this an appreciable cause of difference in the behaviour of the phenomena? What analogies as regards the whole and what modifications as to details will be brought out by a comparison with the Alps? No doubt the interpretation of these differences will always remain a little arbitrary; but it is enough to indicate the question to which they may belong to show the interest which they possess. If it be added that the investigations carried out in the North of Scotland seem to be of a nature to throw some light on the still so obscure subject of the gneissose rocks, it will be seen that they are of an order far surpassing that of a mere regional description. They are, I think, among those that deserve to be presented in some detail to the readers of the "Revue."

Thanks to a courteous invitation from Sir Archibald Geikie, Director-General of the Geological Survey of Great Britain, we were enabled, M. de Margerie and I, to study last summer the region of Assynt, under the guidance of Mr. Peach, who specially directs the work of the Scotch map.[2] Mr. Peach made us verify the principal sections published; we saw with him the irrefutable evidence on which they are based, and we admired the minute accuracy of the survey. Mr. Peach said to us at starting: "I do not think that there is now in the whole of Great Britain any region better or more completely known than that which we are about to visit." We may add, after what we have seen, that in no other part of Europe has it been possible for geological mapping to be carried further, or to do greater honour to its authors.

---

[1] The theory of the cooling of the globe is not free from objections; it is necessary to admit that the earth is at the same time homogeneous, solid, and plastic. These are hypotheses which are certainly not all exact and that are admissible as approximations only. I think, however, that the formulæ may be considered as indicating the drift of the phenomena.

[2] We had the good fortune of making this excursion in the company of Baron von Richthofen, the eminent Berlin professor, Professors Hughes and Sollas, and Messrs. Harker and Watts.

I. Before describing the results of the most recent work, it will be well to say a few words as to that which preceded it. This part of Northern Europe has long been famous for the discussions to which it has given rise. The discovery of fossils in the Durness limestone in 1854 induced Murchison to study the region, and it was he who drew attention to the peculiarities of its structure; a thick series of sediments, quartzites and limestones, rests to the west on the gneisses of the coast, and dips regularly, and at a somewhat low angle, beneath an enormous mass of micaceous schists and of other gneisses, without presenting anywhere indications of interruption or unconformity. Murchison concluded that the upper gneisses were "newer gneisses," and that these must be regarded as Silurian deposits, overlying the fossiliferous beds, and metamorphosed at a later period.

Professor Nicol, of Edinburgh, who accompanied Murchison on his first visit, was the first, on returning to the same investigation in the following years, to propose a different interpretation. He thought that the Silurian quartzites and limestones of the base were repeated several times by folds and by faults; that the conformity with the upper gneisses was only local and apparent, and that in reality there occurred between them a fault along which the gneisses of the east had been pushed over the Silurian. These remarkable views—destined to brilliant confirmation in the future—were supported by a comparison with the known phenomena of the Alps. They were unfortunately not accompanied by those decisive proofs which would at that time alone have caused such innovations to be accepted. Murchison's authority prevailed, and for more than twenty years the existence in Scotland of Silurian gneisses was admitted without discussion, and unreservedly.

The question, taken up from 1878, in the notes of Messrs. Hicks, Bonney, Hudleston, and Callaway, entered upon a new phase upon the publication of the memorable Memoir by Professor Lapworth, entitled "The Secret of the Highlands.[1] Professor Lapworth, in 1882 and 1883, set himself to make a detailed survey of the Durness and Erriboll districts; he was thus led to revive the views of Nicol, but supported this time by decisive proofs.

These proofs were singularly difficult to discover. Fossils were wanting, or nearly so; it was necessary to carry out a stratigraphical study based upon lithological characters only, and in order to do this it was requisite that a sufficient number of precise horizons should be singled out in a series very uniform in appearance, or at least in which there were only two very distinct members. I remember the astonishment, I might almost say the terror, which seized M. de Margerie and myself the first day, when Mr. Peach pointed out to us the characters which differentiated these successive horizons; their apparent insignificance, their almost intangible nature, immediately called forth two thoughts; the first, that one would have been incapable of distinguishing them oneself, and the second, that one must be very bold to establish such grandiose results upon bases of this kind. But these characters, recognized at first in a limited field, were found, ever the same, without modification, for a distance of 150 kilometres. Messrs. Peach and Horne have multiplied the number of these horizons, and their subdivisions, as well as the chief divisions of Professor Lapworth, are repeated in the entire region with the same precision. Each proof, taken separately, would seem of small value; but they are cumulative, and together form an indestructible whole.

---

[1] Geol. Mag. Decade II. Vol. X. 1883, pp. 120, 133, and 137; and Proc. Geol. Assoc. 1884, vol. viii. p. 438.

Professor Lapworth has shown that the apparent enormous thickness of the system was formed by a small number of beds, "piled again and again," and indefinitely repeated, always with the same direction of dip. After this it becomes natural to ascribe the presence of this gneiss above the Silurian to this same phenomenon of "heaping." There the proofs are of another order, and are drawn from the nature of these gneisses and mica-schists; for it can be shown that they have been subjected to tremendous movements, that their particles have undergone a true *re-arrangement*, which, however, allows the recognition here and there of certain portions, less altered, of the ancient gneiss of the coast or of the Silurian divisions. It is to be looked upon as a heterogeneous mass, crushed and pounded by mechanical action and reproducing, in consequence of a sort of general cleavage, the appearance of primitive stratification.

In this way the existence of phenomena, hitherto acknowledged only in certain portions of the Alps, and in the Franco-Belgian coal-field, became recognized in the North of Scotland; the displacement and horizontal carriage of thick superficial masses over several kilometres. Similar examples are now abundant; one led to the other. But ten years ago this was not the case, and I have been told that Professor Lapworth, seized by a kind of fever in facing the consequences which he saw successively opening out before him, in his dreams thought himself caught up in the cogs of these tremendous movements, and crushed along the planes of thrust.

Few geological careers exhibit successes comparable to those of Professor Lapworth. In the South of Scotland, it was by means of Graptolites—lowly organisms of which the palæontological value might appear but slight—that he established horizons in a series that had defied all efforts, and the zones determined in the little corner of Dobb's Linn are now detected all over Europe, and even in America. For the North of Scotland it is with still more insignificant data, with tracks of worms, with lithological differences of colour and grain, that he has fixed his horizons—horizons which, here again, have been found to possess unexpected constancy and extension. By the aid of these tools, forged by himself, and which others would have disdained, he has given the key to the geology of two great provinces of Scotland; he has thus done for the stratigraphy of the Highlands what Sir Archibald Geikie has done for the history of the eruptions of that region, and both names will remain associated with one of the most brilliant phases of Scottish geology.

II. The share of those who have followed Professor Lapworth is sufficiently handsome to enable me, without depreciating their merits, to insist upon those of him who was the *precursor*. The earlier work had shown general affinity to Alpine structure. That of Messrs. Peach and Horne, whilst adding precision to the resemblance, at the same time has brought out differences of which the interest is considerable.

The Geological Survey, although rather prejudiced in favour of the old views, hastened to undertake the general study of the region where the phenomena pointed out by Professor Lapworth could be verified and followed out. Already, in 1884, Mr. Peach, placed in charge of these investigations, was able to invite the Director-General to come and ratify the decisive results which had been obtained, and Sir Archibald Geikie, abandoning the opinion he had hitherto held, lost no time in accepting the evidence of the facts, and in widely announcing the change of view by publishing in "Nature"[1] the conclusions to which the officers of the Survey had been led, step by step, and almost in spite of themselves. But it was only in 1888 that a detailed report was issued embracing the whole of the observations made by Messrs. Peach, Horne, Gunn, Clough, Hinxman, and Cadell.[2] Since then, the observations have been completed, but the Report of 1888 still represents the principal features of the results obtained.

These results are remarkable for more reasons than one. On hearing that the mountains of Scotland showed traces of horizontal displacements comparable to those of more recent mountain ranges, it was possible to suppose that the ancient chain would prove to be constructed on exactly the same plan as the Alps. Later, on finding in the sections of Messrs. Peach and Horne important differences between them and the classical types of Switzerland, it was still possible to believe that these differences might be more apparent than real, and that by varying the method of interpretation they might be reconciled. All such expectation must, I think, be given up; the differences are real and profound; their causes and their theoretical importance can be discussed, but their existence cannot be contested.

To begin with, there are three great planes—or better, three great independent surfaces of "push" or carriage (thrust planes). Each of these has produced horizontal displacements of several kilometres. For the third, the most easterly, these displacements attain 15 kilometres. The first two have brought into superposition above the normal series only beds similar to those which they overlie; the third, on the contrary, has brought a different series into superposition—precisely that of the ancient "recent gneisses" of Murchison. In places, the last thrust plane comes to override the first two; so that there is then a three-storied edifice, the two lower stories built up of the same materials as the basement, and the third formed of different materials. What is more extraordinary, but nevertheless appears to be certain (though I have seen but one example of it, and could not devote sufficient time to its examination), is that the third story does not everywhere rest upon the second, but cuts across the latter obliquely so as to lie upon the first, or even immediately upon the basement. This is an extraordinary complication, of which other instances have not been recognized. Series of thrust planes, arranged one behind the other in *échelon*, and each producing horizontal displacements of several kilometres, are well known, notably in Provence. But each of these thrusts corresponds with a distinct fold; each one has its own domain, and does not trespass upon its neighbour's. In Scotland one cannot resist the impression that one is face to face with a unique phenomenon, and that the division in three folds, each forming one of the three stories, is non-existent.

---

[1] "Nature," 13th November, 1884.

[2] Quart. Journ. Geol. Soc. 1888, p. 378.

There is, however, a difference still more important in my eyes; it is the absence of *inverted beds*. In the Alps and in Provence what characterizes these phenomena of horizontal movements is the more or less intermittent presence of beds succeeding one another in inverse order, the oldest above, the most recent below. These inverted beds are at the same time generally *dragged out*; that is to say, the normal thickness of the divisions is there very greatly reduced. It is these beds that seem to give the clue to the phenomenon and that have allowed Professor Heim to formulate his theory, comparing it to the unfolding of a fold, the base of which, forced to stretch over a larger area, undergoes a kind of rolling out. It would be very easy, it is true, to answer that in Scotland the diminution in thickness has proceeded to zero; that the dragging out process has been carried on so as to become suppression, and the same mechanism can still be resorted to. But there is something further: above each thrust plane there are in Scotland also beds in an abnormal position, only this position is of quite another kind; these beds are oblique to the thrust plane and are indefinitely repeated in consequence of a series of small faults with a hade a little larger than the dip of the beds. In other words, each of our three stories has a *floor*; but this floor, instead of being formed of planks parallel to the base of the story, is as if it had been formed by cutting these planks into slices obliquely uptilted. All these slices are similar among themselves, always sloping to the east, *i.e.* towards the side whence the movement has come, and *the beds are never inverted.* The small separating faults are usually not very obvious, and consequently, finding similar beds recurring over large areas, without apparent horizons, and always dipping in the same direction, one would be led to attribute to them impossible thicknesses. It is here that the utility of the subdivisions introduced in the series becomes manifest: one is confronting a set of *numbered* beds, the numbers of which, though not very distinct, are yet well known and are everywhere recognizable by minute examination. This examination has been carried out in an extraordinarily careful and conscientious manner. In the region visited by us, in the midst of this maze of beds always resembling one another and repeated in narrow compartments, we did not come across a single compartment of which Mr. Peach was not able to show us the detail represented on his plottings on a scale of $\frac{1}{10560}$; not one bed of which Mr. Peach could not beforehand tell us the number.

The arrangement that I have been attempting to describe is exactly what Professor Suess has called *schuppen-structur* (imbricated structure), and it is to be seen produced, in the Bernese Jura for instance, as a particular case of folds; it is, in fact, the structure which one would obtain by imagining a series of folds inclined in the same direction and by further supposing that in all these folds the half corresponding to the inverted beds had been suppressed. What makes the explanation difficult here is the fact that the movement is localized in the floors of the three stories, that is to say in bands of deposits of small thickness; one is at first led, under these conditions, to attribute it to the friction due to the masses which have been moved. It would be easy to suppose that these bands had been plicated by the shearing, as a cloth can be wrinkled by passing the hands over its surface, but it is less easy to conceive how these folds have been replaced by half-folds, or more exactly how the plication can have been replaced by a breaking up into fragments accompanied by a uniform uptilting of the successive fragments.

Without for the present seeking for the meaning and cause of each of these complications, a common character becomes distinguishable: folds are absent or exist only in a concealed form. At least, those that are met with are local accidents which can scarcely be appealed to in explaining the whole of the phenomena. Schematically one can always refer any movement to a fold of which a portion has disappeared; but whereas in the Alps such a disappearance is always momentary and allows the complete fold to reappear at a short distance, in Scotland the disappearance of the inverted portions is constant and almost without exception. In the one case, the explanation by means of folds is the result of direct observation; in the other it is based on *a priori* reasoning. The difference may be expressed in yet another way: in the Alps the suppression of beds is almost always due to sliding parallel to the stratification, and I have attempted in a previous article[1] to explain that this was a natural consequence of the parallelism between the beds and the forces of compression. In Scotland there is the same parallelism and yet the slides, with the exception of the three great thrusts, are almost always oblique to the stratification of the deposits. For so complete a change there must certainly be a general and deep-seated cause. This cause cannot reasonably be sought for in the nature of the forces in action; it must therefore depend upon the resistances brought into play. A remarkable series of experiments by Mr. Cadell, partly carried out with the collaboration of Mr. Peach, is perhaps such as to throw some light upon the question.[2]

---

[1] Revue générale des Sciences, t. iii. p. 1.

[2] Trans. Royal Soc. Edinburgh, vol. xxxv. part ii. p. 337.

It was necessary to use substances capable of plication within certain limits, but incapable of supporting a greater strain without fracture; alternations of plaster of Paris and damp sand fulfilled this condition; moreover, deformation was allowed free play by not weighting by the addition of any foreign body the mass of compressed beds. This was to deviate appreciably from the natural conditions where the weight of the beds, owing to the magnitude of the masses in motion, plays a considerable part, whilst in the experiment this action is negligeable. On the other hand, if by these means structures are produced comparable with those of the Highlands, one may conclude that the causes of the peculiarities presented are connected with a diminished *plasticity*, due either to the nature of the beds, or rather to their diminished thickness. It is, indeed, admitted now, following Professor Heim, that the plasticity to which the folds of mountain beds testify is due, on the one hand, to the slowness of the movements, and, on the other, to the enormous weight with which the folded parts were charged. For solid bodies, with sufficient pressure, the distribution of this pressure becomes, as with liquids, equal in every direction; and then, even if the cohesive forces be overcome, the particles, energetically maintained from all sides, are incapable of any but very slight relative motion; the body is deformed progressively, and without breaking.

As a matter of fact, Mr. Cadell's experiments reproduced with surprising fidelity some of the singular sections described in Scotland, notably the superposed thrust planes, and the beds piled up over themselves. The starting point is always the formation of a fold; but the beds thus brought in relief, being no longer sustained laterally, break, and their fragments transgress one over the other; the fold remains visible in the depth, although its form has disappeared from the surface owing to this kind of breaking up into pieces. As regards the piling up, the experiments produce it only in the upper portion of the system, almost always above a thrust plane, and as an extreme case of the collapse of an arch. The friction exerted by an upper thrust plane therefore plays no part here, and one is led to think that it may have been so likewise in the natural phenomenon, or at least that the friction above has only intervened so far as to cause the piled up fragments to lie in the direction of the movement, and to dispose them more horizontally. In other words, the slices of piled up beds would represent slices which have advanced further than that which is above them, and not so far as that which is beneath; and which, moreover, because of their small thickness, have undergone in a greater measure the retarding or accelerating action of the masses between which they lay. In this form, it will be at once perceived that the formula can be generalized, and gives in a very simple manner the general explanation of the phenomena; the thrust masses have been split up into a series of horizontal slices which have moved independently of one another;[1] the thick masses in one piece, the others subject to the secondary influence of the neighbouring masses. Taken thus, this formula only differs from that by which I attempted before to summarize the Alpine movements in that, as regards the latter, the successive slices are precisely the beds themselves, the planes of division being the planes of stratification, and therefore almost indefinite in number. In Scotland, as in the Alps, the pressures at first would form an arch, then, as they became greater, the arch in the one case would be bent downwards, and in the other would break. Pressure continuing, sliding movements would take place, following the bedding in the reclining fold, and following the fractures in the broken one. The difference between the two regions would be due to a difference in plasticity, *i.e.* to a difference of weight or thickness in the masses compressed. It will be seen how well this explanation agrees with the theory,[1] according to which the thickness of the superficial rocks compressed in consequence of the cooling of the earth increases with time. The differences between the mountains of Scotland and the Alps would be *a question of time.* No doubt this is yet but a hypothetical consequence; it may be added, however, that it is further confirmed by a comparison with the Coal-measure range. This chain, so well studied by Prof. Gosselet in the Ardenne, presents, on the borders of the coal-field, an intermediate structure, the part played by faults being there more accentuated than in the Alps, and less so than in Scotland. In any case, I cannot share Mr. Cadell's opinion when he says that in examining the Alps by the light of the new facts recognized in the Highlands, and confirmed by laboratory experiments, the same structures will be found there. It is not the observers who are at fault, it is the mountains which are not the same.

---

[1] This is exactly the formula which I proposed two years ago, when pointing out

III. Side by side with the study of the movements themselves must be noted that of the metamorphism due to them. Nowhere, perhaps, outside the works of Reusch, in Norway, have clearer or more instructive examples been described. In the conglomerates, pebbles are seen to lengthen in the direction of the movement, sericite is developed in the quartzites, transforming them into micaceous schists traversed by little felspathic veins ("veins of pegmatite"). All these effects go on increasing as one approaches the east, and beneath the last great thrust plane we were enabled to see a remarkable section where, by reason of the repetition of the beds, one can follow almost step by step the progress of transformation, to a point at which the beds altogether cease to be recognizable, and can no longer be distinguished from the mass of crystalline schists ("Moine Schists") which surmount them.

At other points, on the contrary, where the upper "story" (in consequence of a lesser degree of denudation) advances further to the west, the separation of the two systems is clear and distinct; there is then found at the base of the crystalline schists a veritable

---

that the Scottish sections exhibited the material realization of this theoretical idea. Comptes Rendus Acad. Sci. 29th December, 1890, Report of M. Daubrée on the "Vaillant" prize.

[1] Davison and Darwin, Phil. Trans. Roy. Soc. 1887, p. 281.

friction breccia several metres thick in which the broken fragments are visible to the naked eye, but which is divided into parallel layers and appears stratified. The bedding is here evidently mechanical; it is a cleavage of the broken mass. For Mr. Peach the phenomenon is the same when the fragments cease to be visible and when they melt into an entirely crystalline paste. Everything then, the texture of the rock, as well as the appearance of sedimentation or its crystalline structure, would be the result of mechanical action, and that over an area of some thousands of square kilometres. It would even not be necessary to regard this enormous mass of schists as corresponding to any particular stage; the materials of which it consists would be furnished pell-mell by the rocks and deposits anterior to the movements. Here the hypothesis becomes somewhat too colossal to enable one to associate oneself with it. It seems to me difficult not to see in these crystalline schists as a whole, one special formation of definite age, which if not yet determined is certainly anterior to the Cambrian, a true stage (*étage*) in the ordinary acceptation of the term, and more or less to be likened to the micaceous schists and slates (*phyllades*) which in France form the top of the crystallophyllian series. It may be admitted that the apparent thickness of this group is augmented by a series of thrust planes and by the mechanical piling up already described; it may also be admitted that the visible bedding is cleavage. But in the absence of new arguments one can scarcely go further; the still recognizable patches of ancient gneisses or of Silurian beds found within the mass, must be considered as more ancient or more recent parts brought in by folds or by faults; but they cannot bear out the conclusion that the whole mass was formed of the same materials. As to the sudden appearance of a thick sedimentary series entirely wanting a few kilometres to the west, it reminds one exactly of what takes place in the Alps in the zone between the *massifs* of Mont Blanc and Monte Rosa. It would even be possible to follow, member by member, a curious correspondence in position between the series of the two regions: the gneisses of the Mont Blanc chain would tally with those of the Scottish coast; on these gneisses rest unconformably on the one hand the Carboniferous deposits, on the other the Torridon Sandstones of which I shall speak presently; the quartzites and limestones of the Trias take the place of the Cambrian quartzites and limestones of Scotland, and, east of the last named, instead of seeing a reappearance of the older divisions over which they lie to the west, we encounter only an immense succession of schists unknown on the other side, the *Moine schists* in Scotland and the lustrous schists in the Alps. In these last, moreover, patches of Trias are found intercalated, as shreds of Cambrian are enclosed in the schists of Scotland.

This is, however, not the place to insist upon these *Moine Schists*, the question which of all others remains the most obscure, and on which next to nothing has been published. The last observations I wish to mention in concluding are those relating to the gneiss rocks of the coast. There the post-Cambrian movements are no longer felt; the prodigiously dislocated region which we have been studying is succeeded by another where reigns the appearance of the most complete calm, where the gneisses themselves are but feebly and gently undulated, where the sandstones which overlie them have almost everywhere remained horizontal. These sandstones (Torridon Sandstone), of which I have already said one word, recall the aspect of our Permian stage by their coarsely detrital nature and by their red and brown colour; in their entire thickness, which is great, there is no trace of metamorphism. They are, however, incontestably older than the Cambrian quartzites everywhere to be seen resting unconformably with a slight dip to the east on the slices of the obliquely cut horizontal sandstones. Erosion has deeply sculptured these sandstones into isolated peaks of quaint and abrupt shapes, like immense fortresses guarding the coast-line; strangers, as MacCulloch said—the first geologist who described them—by their nature and by their structure to all that surrounds them, they seem astonished to find themselves where they are. Their horizontality, their freshness, their resemblance to more recent deposits, these are so many indications that the basement on which they rest has itself remained much as it was in those ancient times. What can be studied at their base then are the gneisses such as they were before the Cambrian epoch.

This is a point of great importance; it is owing to circumstances of this kind that the study of the gneisses will always be easier and more fruitful in more northern countries than in ours. Where the Earth's crust has been dislocated up to more recent times, the gneisses are only exhibited to us with all the transformations due to metamorphism and to the successive injection of igneous rocks. It does not appear that this complexity has given rise to special types (though I do not think that a serious study, without preconceived views, has yet been carried out in this direction); but at any rate such a complexity renders it more difficult to assign to each agent the part it may have played. Where on the contrary, as in Scotland, deformation has stopped at its first stage, the problem is simplified, and the chances are greater that precise conclusions may be arrived at.

The gneisses of the Scottish coast are basic gneisses, in which the mica is replaced by amphibole or pyroxene; they are granitoid gneisses, *i.e.* the arrangement of the dark-coloured materials along parallel lines is but faintly indicated in them. They are traversed by numerous basic veins, from diabases to peridotites, and all anterior to the Torridon Sandstone. These gneisses, as I have said, constituted the platform against which the tremendous flood of the Silurian displacements stopped without shaking it; but in it are found traces of more ancient movements, later than the basic veins, and prior to the Torridon Sandstone. These movements it has been possible to study in detail, and they have yielded precious data.

They are narrowly localised along lines or bands of small breadth, compared by Mr. Peach to vertical thrust planes; along these lines, which sometimes follow the veins, the latter are transformed into hornblende schists, with a little mica and lenses of dioritic matter; the peridotites pass into talcose schists. In the gneisses there is mica formed in lines along the direction of the movement; the new planes of orientation are independent of the primitive foliation, which they cut across, and sometimes obliterate completely, and all the stages of the changes can be followed. It will be seen, since the original foliation here plays no part, that the result would have been the same in a granite; one is assisting, in fact, *at the formation of gneiss, and of amphibolic schists, by means of the foliation of granitoid rocks.* This theory has already been several times proposed, and has been cited in support of other observed facts; but I do not think that any of these facts can present themselves more clearly or offer an easier verification than those under consideration.

It may be objected that the effect is produced in narrow areas only; but it is so by a phenomenon which is only exceptionally localised, and which, from what is known of its other effects, is capable of extension over masses of almost indefinite size. One is thus in a position to conclude that the foliation of eruptive rocks is one of the possible and even probable modes of formation of gneiss. In the first place, as has been seen already, the same mechanical metamorphism may be applied to sedimentary rocks. Moreover, M. Michel Lévy has proved that the injection of eruptive into sedimentary rocks can equally produce true gneisses: perhaps only in this case is it less easy to conceive of the extension of the phenomenon to vast areas. Lastly, there may be gneisses formed originally and directly in the state of gneiss, corresponding in such a case to the first crust of the solidified globe. Dr. A. C. Lawson has described an interesting example of this in Canada, which would approximate this mode of formation to that of the eruptive rocks. Here are, then, three possible origins, outside all theory, and it must be owned that choice, in the present state of knowledge, is very seldom possible for each particular case. The observations of Messrs. Peach and Horne mark, however, a further step towards the solution, and what L. von Buch said of the Tyrol may be repeated here. All geologists who take up these questions should make a pilgrimage to the Scottish coast.

In concluding this summary, it remains to me to express the desire that these beautiful discoveries may be, as soon as possible, published in all their details. The Report of 1888 is but a *résumé* of the most important facts; one has a right to expect, and to demand, a complete monograph. All the elements of such a monograph will soon be gathered together; they must be made public. It is desirable that a micrographic study should accompany and give precision to all the observations relating to metamorphism, and especially that it may be possible to follow the perusal of the Memoir on detailed maps. An immense amount of labour has been undergone in carrying out this survey: the reduction to a scale one-sixth of that of the original maps will cause an almost inextricable complication of lines, and the loss of the benefit of part of the work. The region presents an interest sufficiently exceptional, and sufficiently general, to raise it above the rules of ordinary routine, and the question of cost is not an obstacle. England is rich enough to pay for its glory.

II.—ON A METEORIC STONE FOUND AT MAKARIWA, NEAR INVERCARGILL, NEW ZEALAND. By G. H. F. ULRICH, F.G.S., Prof. of Mining and Mineralogy in the University of Dunedin, New Zealand. (Proc. Royal Society, London, 1893.)

THE specimen described in this Memoir was found in the year 1879, in a bed of clay, which was cut through in making a railway at Invercargill, near the southern end of the Middle Island of New Zealand. Originally this meteorite appears to have been about the size of a man's fist, and to have weighed 4 or 5 lbs., but it was broken up, and only a few small fragments have been preserved. The stone evidently consisted originally of an intimate admixture of metallic matter (nickel iron) and of stony material, but much of the metallic portion has undergone oxidation. Microscopic examination of thin sections shows that the stony portion, which is beautifully chondritic in structure, contains olivine, enstatite, a glass, and probably also magnetite, and through these stony materials the nickel iron and troilite are distributed. The specific gravity of portions of the stone was found to vary between 3·31 and 3·54, owing to the unequal distribution of the metallic particles. A partial chemical examination of this meteorite was made by the author and Mr. James Allen, but the complete analysis has been undertaken by Mr. L. Fletcher, F.R.S., of the British Museum. The analysis, which, when finished, will be communicated to the Royal Society, has gone so far as to show that the percentage mineral composition of the Makariwa meteorite may be expressed approximately by the following numbers; nickel iron 1, oxides of nickel and iron 10, troilite 6, enstatite 39, olivine 44.

REVIEWS.

I.—AN INTRODUCTION TO THE STUDY OF THE GENERA OF PALÆOZOIC BRACHIOPODA. Part I. By JAMES HALL, assisted by JOHN M. CLARKE. Geological Survey of the State of New York. Palæontology. Vol. VIII. 1892. Large 8vo. pp. xvi. 367, with 43 Plates.

IN many valuable volumes Professor Hall has described the Palæozoic fossils of the State of New York. In the long series of years during which he has been labouring in his appointed field, progress has necessarily been made in other lands and by other workers. Consequently, work that was admirable twenty years ago runs some risk of being overlooked at the present day unless it is brought into line with recent discoveries. To summarise and consolidate the knowledge of the past enables us to appreciate better both the perfections and imperfections of our science, and affords the surest ground for further progress. This is the task that is now being attempted for Palæozoic Brachiopoda by Messrs. Hall and Clarke, and the first-fruits of their toil are seen in the volume before us.

The plan of this work is to describe very completely each genus and sub-genus, comparing it with allied genera and referring to it the more important species both of America and Europe. At the same time a good bibliography is given of each genus, and every attempt made to ensure that it shall receive the name by which its first author intended that it should be known. So far as the work is at present carried, it deals with the genera usually classed as Inarticulata or Tretenterata, and with those genera of the Articulata that may naturally be grouped around *Orthis, Leptæna, Chonetes,* and *Productus.* The second part, which we are glad to learn is already far advanced, will deal with the spire-bearing and terebratuloid forms. No attempt is made to group the genera in families, for the authors consider that such a classification would be "arbitrary and procrustean, and would only be embarrassing to the student without any corresponding benefit." The relationships of the genera are, however, treated of in separate chapters.

The casual reader of this work will note, perhaps with dismay, a very large number of new generic names. The authors, indeed, confess that they have used "as many terms of this value as are in any way justifiable." They assure us, however, that the future will prove some of these generic groups to be still too broad; and no student of the recent progress of systematic zoology can venture to contradict them. Such new terms are: *Barroisella* (type, *Lingula subspatulata,* M. & W.); *Tomasina* (type, *Lingula Criei,* Dav.); *Discinopsis* (type, *Acrotreta*? *Gulielmi,* Matthew); *Œhlertella* (type, *Discina pleurites,* Meek); *Lindstroemella* (type, *L. aspidium,* n. sp.); *Rœmerella* (type, *Discina grandis,* Vanuxem); *Plectorthis* (type, *Orthis plicatella,* Hall); *Dinorthis* (type, *Orthis pectinella,* Emmons); *Plæsiomys* (type, *Orthis subquadrata,* Hall); *Hebertella* (type, *Orthis sinuata,* Hall); *Heterorthis* (type, *Orthis Clytie,* Hall); *Dalmanella* (type, *Orthis testudinaria,* Dalman); *Orthotichia* (type, *Orthis*? *Morganiana,* Derby); *Billingsella* (type, *Orthis Pepina,* Hall); *Protorthis* (type, *Orthis Billingsi,* Hartt); *Polytœchia* (type, *Hemipronites apicalis,* Whitf.); *Orthidium* (type, *Orthis gemmicula,* Bill.); *Kayserella* (type, *Orthis lepida,* Schnur); *Rafinesquina* (type, *Leptæna alternata,* Conrad); *Leptella* (type, *Leptæna sordida,* Bill.); *Christiania* (type, *Leptæna subquadrata,* Hall); *Chonostrophia* (type, *Chonetes reversa,* Whitf.); *Chonopectus* (type, *Chonetes Fischeri,* Norw. and Pratt.). After this it is reassuring to find that certain old and well-known names have not entirely disappeared, although the sense in which they are retained is rather different from that attributed to them of recent years. Thus, *Orthis* proper is here restricted to a small group of species of which *Orthis callactis* is the type; *Strophomena* is at last applied to the species for which Rafinesque originally intended it, viz. *Leptæna planumbona,* Hall, while *Leptæna* naturally returns to the well-known species that for the first thirty years of its existence was acknowledged as its type, the *Conchites rhomboidalis* of Wilckens or *Producta rugosa* of Hisinger, a fossil that has for many years usurped the title of *Strophomena.* It will be noticed that these changes, and others that might be mentioned, such as the restitution of *Clitambonites,* Pander, to the place from which it was ousted by D'Orbigny's *Orthisina*, are no resuscitation of "rusty rubbish," but are simply a return to names that were actually used by scientific writers until, through ignorance or impudence, other names were substituted for them. Those critics who raise such an outcry over changes of nomenclature would often find, if only they would take the trouble to look into matters, that the names they take upon themselves to defend are but modern upstarts after all. In considering a question so vast and so far-reaching as this of nomenclature, we must take into account not merely our own short lives, nor even the poor hundred years that comprise the history of systematic zoology, but the centuries that are to come and the posterity for whom, if for anyone, we ourselves are working. The student of 2093, should he have occasion to consider the literary history of the name *Leptæna*, will regard the thirty years of its application to *Plectambonites transversalis* as nothing more than a temporary aberration.

It would be impossible to indicate in these pages half the interesting deductions of the authors, deductions that derive very great importance from the extended nature of the facts and philosophical character of the arguments on which they are based. A slight sketch of some of their results with regard to the Inarticulata will, however, serve as an example of their method.

Hitherto the muscle-scars have been taken as features of supreme classificatory importance, but the uncertainty and frequent obscurity of these characters lead the authors to subject them to the nature of the pedicle-passage, a point in which they agree with Dr. C. E. Beecher. In its early stages of shell-growth, *Lingula* recalls the features of obolelloid shells, a type that culminated before *Lingula* appeared on the scene; while *Lingulella* and *Lingulepis*, which precede *Lingula*, are actual links in which the shape of *Lingula* is combined with the narrow pedicle-slit and simple muscle-arrangement of the obolelloids. Our authors favour the opinion, which was beginning to lose ground, that *Lingula* has persisted from the Silurian to the present day; numerous branches, however, have been given off by the way. Thus, an increased secretion of shelly substance, or stereom, about the insertions of the muscular and parietal bands produced the median and lateral septa that characterize *Dignomia* and the more recent *Glottidia*. *Obolella* is another important genus from which other forms may be traced. In one direction, as just mentioned, it is connected with *Lingula* by way of *Lingulella*. Similar specialization of muscles, combined however with retention of the circular form, leads to *Obolus*, whence arise in different directions *Leptobolus*, *Schmidtia*, *Paterula* and *Schizobolus*.

It has of late been forcibly impressed on us that the same structure may appear along different lines of development, and to this the Brachiopoda are no exception. On *a priori* grounds one would hardly be prepared to admit that the two divisions, Articulata and Inarticulata, represent divergent branches; one would rather imagine that the Articulata must have been derived from the Inarticulata at numerous points. We now know that in many respects the more highly organised of the Inarticulata do approach the Articulata. To consider only one character, the formation of a hinge: in *Barroisella*, a descendant of *Lingula*, the deltidial callosities are developed to such a degree as to indicate their specialization for purposes of articulation; in *Spondylobolus* a similar result appears to have been arrived at by way of *Obolella*. *Trimerella* and *Monomerella* similarly tend to develop articular processes in their pedicle-valve, while *Neobolus* has a strong cardinal process in its branchial valve. It does not, however, appear that as yet any distinct connection can be established between articulate and inarticulate genera.

Another structure arrived at along two distinct lines is the platform of the so-called Trimerellidæ, a family that, if the authors' conclusions are correct, can of course no longer be maintained. This platform has been evolved by the raising of the anterior edges of the stereom at the bases of the central and lateral muscles, a raising which the authors suggest is due to displacement of, and pressure against, the liver; this has induced a thickening of the entire area of muscle-attachment, and the solid plate so formed has been gradually excavated and changed into a more or less vaulted platform. The authors show that this evolution has proceeded from *Lingula* through *Lingulops* and *Lingulasma* to *Trimerella*, and again from *Obolus* through *Elkania* to *Dinobolus*. It is remarkable that both these lines should have culminated at the close of the Silurian period, both in the Guelph Limestones of Canada and in the uppermost beds of Gotland; but we would ascribe this to the natural working of the laws of growth rather than to any specially favourable conditions of the later Silurian sea.

Into their further investigations we forbear to follow these authors; this, however, is the less to be deplored, since a perusal of their work is not only absolutely necessary for the student of the Brachiopoda, but should prove both pleasant and instructive to all naturalists. For the book is written in a clear and interesting manner,—not too greatly marred by such phrases as "a series eventuates," "the edentulous brachiopods," "features approach desuetude" and "to fortify a view," and entirely free from the horrible jargon of "naepionic," "clinologic," "ephebolic" and the rest, that renders almost unintelligible some of the most valuable and suggestive American work; and there are besides 43 plates filled with figures most appropriately selected by the authors and admirably rendered by the artists.

The large list of those in the United States, Canada, and the different countries of Europe, to whom Prof. Hall acknowledges his indebtedness, is a pleasing instance of that "federation of the world" in which scientific men are far ahead of politicians; and the bibliographic tables supplied by Mr. Charles Schuchert show that, at least to students of the Brachiopoda, the walls of Babel prove no hindrance.

F. A. Bather.

II.—Annals of British Geology, 1891. A Digest of the Books and Papers published during the year; with Occasional Notes. By J. F. Blake, M.A., F.G.S., etc. 8vo. pp. x.–434; 6 Plates. (London: Dulau & Co., 1892.)

We welcome with much pleasure the second issue of this extremely useful work of reference, which deserves the support of all British geologists. It contains the titles and abstracts of 650 papers, or 90 more than that of last year. These are arranged under the headings of: General Geology; Stratigraphical Geology; Palæontology; Mineralogy; Petrology; Economics; Maps and Sections; Foreign Geology (published in Britain); Misplaced; Supplement for 1890. The section next to the last is "misplaced" as to its heading rather than as to its matter, and would more correctly have been styled "addenda." The most important addition to the present volume is that of the plates. Of these two are maps, the others reproductions of the illustrations of new fossils, etc.; but we fail to see how these can be maintained as a feature in such a record.

It is satisfactory to note that the remarks of the compiler, which in the previous year were intercalated between [ ] in the text, and which gave rise to some sharp discussions, are this year confined to notes, and fortunately fewer in number, though even now capable of further reduction. It is hardly necessary to take up a line of footnote to call attention to an obvious misprint of a 3 for an 8 (p. 50); nor do such notes as that on p. 57 help anybody. The wise recorder obtrudes his personality as little as possible.

The patience and industry shown in reproducing lists of fossils is most praiseworthy; but one can have too much of a good thing, and where a work practically consists entirely of such, it is hardly worth while to reproduce it, as in one instance, which covers nine pages of these annals, even when the 585 worthless MS. names of the original are omitted.

Space might with advantage, too, be gained in future by omitting the section "Foreign Geology (published in Britain)," which necessarily being but the fragment of a larger record is valueless, because incomplete, and lies moreover without the scope of "British Geology."

It is a great pity that in the case of works of this sort their value really begins only when a number of years have been completed; one or two volumes alone are practically of little moment. Under these circumstances all the more credit attaches to the individual who, single-handed, has the pluck to undertake so risky a venture, and that at a time when Geological Records in this country, at all events, are not in particularly high favour.

We trust that the means will be forthcoming to enable Professor Blake to continue a work so well begun, for, as he warns us in his preface, "the series can only be continued beyond a third volume if it be made, at least, self-supporting." Geologists as a body are not wealthy, but are, nevertheless, ever ready to contribute individually their mite to a good cause; whilst, as to the wealthy few, *verb. sap. suff.*

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—January 25th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read :—

1. "On Inclusions of Tertiary Granite in the Gabbro of the Cuilin Hills, Skye; and on the Products resulting from the Partial Fusion of the Acid by the Basic Rock." By Prof. J. W. Judd, F.R.S., V.P.G.S.

The author first calls attention to previous literature bearing on the subject of the extreme metamorphism of fragments of one igneous rock which have been caught up and enveloped in the products of a later eruption. The observations of Fischer, Lehmann, Phillips, Werveke, Sandberger, Lacroix, Hussak, Graeff, Bonney, Sauer, and others show that, while the porphyritic crystals of such altered rocks exhibit characteristic modifications, the fused ground-mass may have developed in it striking spherulitic structures.

On the north-east side of Loch Coruiskh, in Skye, there may be seen on a ridge known as Druim-an-Eidhne, which rises to a little over 1000 feet above the sea, a very interesting junction of the granitic rocks of the Red Mountains with the gabbros of the Cuilin Hills. At this place, inclusions of the granitic rock, sometimes having an area of several square yards, are found to be completely enveloped in the mass of gabbro. The basic rock here exhibits all its ordinary characters, being a gabbro passing into a norite, traversed by numerous segregation veins; the acid rock is an augite-granite, exhibiting the micropegmatitic ("granophyric") and the drusy ("miarolitic") structures, and it passes in places into an ordinary quartz-felsite ("quartz-porphyry").

Within the inclusions, however, the acid rock is seen to have undergone great alteration from partial fusion, and it has acquired the compact texture and splintery fracture of a rhyolite; weathered surfaces of this rock are found to exhibit the most remarkable banded and spherulitic structures.

Microscopic study of the rock of these inclusions shows that the phenocrysts of quartz and felspar remain intact, but exhibit all the well-known effects of the action of a molten glassy magma upon them. The pyroxene, however, has been more profoundly affected, and has broken up into magnetite and other secondary minerals. The micropegmatitic ground-mass, which was the last portion of the rock to consolidate, has for the most part been completely fused, and in some places has actually flowed. In the glassy mass thus formed, the most beautiful spherulitic growths have been developed, the individual spherulites varying in size from a pin's head to a small orange. These spherulites are often composite in character, consisting of minute examples of the common type enclosed in larger arborescent growths ("porous-spherulites") of felspar microlites, with silica, originally in the form of opal and tridymite, but now converted into quartz, lying between them. All the interesting forms of spherulitic growth which have been so well described by

Mr. Iddings from the Obsidian Cliff in the Yellowstone Park, and by Mr. Whitman Cross from the Silver Cliff, Colorado, are most admirably illustrated in these inclusions of the Cuilin Hills. It is interesting to note that the nuclei of some of these large spherulites consist of fragments of the micropegmatitic granite which have escaped fusion. Among the new minerals developed in these inclusions, by the action on them of the enveloping magma, are pyrites and fayalite (the iron-olivine).

The phenomena now described are of interest as setting at rest all doubts as to the order of eruption of the several igneous masses of the Western Isles of Scotland. That the gabbros are younger than the granites was maintained by Macculloch in 1819, by J. D. Forbes in 1846, by Zirkel in 1871, and by the author in 1874. In 1888, however, Sir A. Geikie asserted that these conclusions were erroneous; he insisted that the granites were erupted *after* the gabbros and basalts, and that they are, indeed, later than all the volcanic rocks of the district except a few basic dykes which are seen to traverse them. The occurrence of the remarkable inclusions of granite within the gabbro now removes all possibility of doubt on the subject, and proves conclusively that the granite was not only erupted but had consolidated in its present form before the outburst through it of the gabbro.

2. "Anthracite and Bituminous Coal-beds. An attempt to throw some light upon the manner in which Anthracite was formed; or contributions towards the controversy regarding the Formation of Anthracite." By W. S. Gresley, F.G.S.

The author does not seek to advance any new theory in this communication, nor to proclaim new facts of any importance, but to put old facts in something of a new light, in order to aid the investigations of others. His main object is to establish two facts, viz. :—that the associated strata of anthracite-beds are more arenaceous than those containing so-called bituminous coal-beds, and that the prevailing colours of the sandstones, grits, etc., of anthracite regions are greyer and darker than those of regions of bituminous coal. To these facts may perhaps be added a third, that the more anthracitic the coal-beds, and the more siliceous the enclosing strata, the harder and tougher these associated strata are.

While recognizing that the rocks of many anthracite regions have undergone great disturbance, he cites other areas where coal-basins have been much folded, without any corresponding production of anthracite in considerable quantity.

The modes of occurrence of anthracite are illustrated by many instances observed by the author in the Old and New Worlds.

II.—February 8th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

1. "Notes on some Coast-Sections at the Lizard." By Howard Fox, Esq., F.G.S., and J. J. H. Teall, Esq., M.A., F.R.S., F.G.S.

In the first part of the paper the authors describe a small portion of the west coast near Ogo Dour, where hornblende-schist and serpentine are exposed. As a result of the detailed mapping of the sloping face of the cliff, coupled with a microscopic examination of the rocks, they have arrived at the conclusion that the serpentine is part and parcel of the foliated series to which the hornblende-schists belong, and that the apparent evidences of intrusion of serpentine into schist in that district are consequences of the folding and faulting to which the rocks have been subjected since the banding was produced. The interlamination of serpentine and schist is described. and also the effects of folding and faulting. Basic dykes, cutting both serpentine and schists, are clearly represented in the portion of the coast which has been mapped, and these locally pass into hornblende-schists, which can, however, be clearly distinguished from the schists of the country. The origin of the foliation in the dykes is discussed.

The second part of the paper deals with a small portion of the coast east of the Lion Rock, Kynance. Here a small portion of the "granulitic series" is seen in juxtaposition with serpentine. The phenomena appear to indicate that the granulitic complex was intruded into the serpentine; but they may possibly be due to the fact that the two sets of rocks have been folded together while the granulitic complex was in a plastic condition, or to the intrusion of the serpentine into the complex while the latter was plastic.

2. "On a Radiolarian Chert from Mullion Island." By Howard Fox, Esq., F.G.S., and J. J. H. Teall, Esq., M.A., F.R.S., F.G.S.

The main mass of Mullion Island is composed of a fine-grained "greenstone," which shows a peculiar globular or ellipsoidal structure, due to the presence of numerous curvilinear joints. Flat surfaces of this rock, such as are exposed in many places at the base of the cliff, remind one somewhat of the appearance of a lava of the "pahoehoe" type.

The stratified rocks, which form only a very small portion of the island, consist of cherts, shales, and limestone. They occur as thin strips or sheets, and sometimes as detached lenticles within the igneous mass. The chert occurs in bands varying from a quarter of an inch to several inches in thickness, and is of radiolarian origin. The radiolaria are often clearly recognizable on the weathered surfaces of some of the beds, and the reticulated nature of the test may be observed by simply placing a portion of the weathered surface under the microscope.

The authors describe the relations between the sedimentary and igneous rocks, and suggest that the peculiar phenomena may be due either to the injection of igneous material between the layers of the stratified series near the surface of the sea-bed while deposition was going on, or possibly to the flow of a submarine lava.

The forms of the radiolaria observed in the deposit, and also their mode of preservation, are described in an Appendix by Dr. G. J. Hinde.

3. "Note on a Radiolarian Rock from Fanny Bay, Port Darwin, Australia." By G. J. Hinde, Ph.D., V.P.G.S.

A specimen brought from Fanny Bay by Captain Moore, of H.M.S. "Penguin," is of a dull white or yellowish tint, in places stained red. It has an earthy aspect, and is somewhat harder than chalk, but gives no action with hydrochloric acid. Microscopic sections show a fairly transparent ground-mass, apparently amorphous silica, containing granules and subangular fragments up to ·075 millim. in diameter, some of which appear to be quartz.

Besides this, the rock contains numerous radiolaria, and it is really a radiolarian earth intermediate in character between the Barbados earth and such cherts as those of the Ordovician strata of Southern Scotland.

The details of the extent of the deposit and its relationship to other rocks of the area are not yet obtainable, though it is possible that a considerable thickness of rock mentioned by Mr. Tenison Woods as occurring in this area may also be of radiolarian origin.

The author describes a species of *Cenellipsis*, two of *Astrophacus*, one of *Lithocyclia* (new), one of *Amphibrachium*, three of *Spongodiscus* (one new), four of *Spongolena* (all new), two of *Dictyomitra* (both new), one of *Lithocampe* (new), and two of *Stichocapsa* (both new).

From these it is not practicable at present to determine the geological horizon of the rock; with one exception, all the genera represented occur from Palæozoic times to the present.

4. "Notes on the Geology of the District west of Caermarthen." Compiled from the Notes of the late T. Roberts, Esq., M.A., F.G.S. (Communicated by Prof. T. McKenny Hughes, M.A., F.R.S., F.G.S.)

To the east of the district around Haverfordwest, formerly described by the author and another, an anticlinal is found extending towards Caermarthen. The lowest beds discovered in this anticline are the *Tetragraptus*-beds of Arenig age, which have not hitherto been detected south of the St. David's area. They have yielded eight forms of graptolite, which have been determined by Prof. Lapworth. The higher beds correspond with those previously noticed in the district to the west; they are, in ascending order: (1) Beds with "tuning-fork" *Didymograpti*, (2) Llandeilo limestone, (3) *Dicranograptus*-shales, (4) Robeston Wathen and Sholeshook Limestones.

Details of the geographical distribution of these and of their lithological and palæontological characters are given in the paper.

Glasgow Geological Society, Dec. 8.—Mr. Dugald Bell, F.G.S., read a paper "On the Origin of certain Granite Boulders in the Clyde Valley." He referred to the opinion expressed by the late Mr. Smith of Jordanhill, many years ago, that a number of these boulders around Glasgow had been derived from the neighbourhood of Ben Cruachan. With all respect to so eminent an authority, this seemed impossible, as according to the evidences of glaciation in the intervening district, such boulders would have to traverse at least two great sheets of land-ice moving in quite a different direction, viz. southward and south-westward, instead of eastward as required. Besides, the granite of the boulders referred to is strikingly different from the Ben Cruachan granites. Judging from the ice-marks, he (Mr. Bell) had long thought that the locality in which these boulders originated was to be found in the mountainous tract between the head of Lochlomond and the head of Lochfyne. More than thirty years ago the late Prof. James Nicol, of Aberdeen, in his "Geological Map of Scotland," had indicated two limited areas of granite in that region, but the later maps of Murchison (1861) and Geikie (1874) contained no such indications. On a recent visit to St. Catherine's, opposite Inveraray, he had been struck by the enormous number of granite boulders, quite resembling those under notice, which lay strewn at that point along the eastern shore of Lochfyne, and it seemed impossible that these could have come across the loch, all the evidences of glaciation being strongly southward. He had, therefore, been convinced that the parent locality of these boulders was not far distant, probably in the upper part of Glenfyne. Though he had not as yet found leisure to make a personal exploration, he thought the conclusions he had arrived at were confirmed, indeed proved by the officers of the Geological Survey, who had lately described a granitic tract of about ten square miles on the eastern side of the northern part of Glenfyne, extending to, and slightly beyond, the water-shed between it and Glen Falloch. He further pointed out how from this locality, by Loch Eck and the Holy Loch, by Loch Long, and partly by Lochlomond, land-ice bearing the boulders in question could have reached the various points at which they had been found. At the close of the paper some discussion took place, the speakers generally agreeing with Mr. Bell in the conclusion at which he had arrived.

CORRESPONDENCE.

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—I shall feel obliged if you will allow me to amend the sentence "Mammoth from the Lower Glacial Gravel at Finchley" in my letter in the last Number of the Geological Magazine, by substituting *Elephas* for Mammoth as being more correct, as the specimens are not such as would enable us to identify the species. In the other cases cited the bones were undoubtedly those of the Mammoth.
Henry Hicks.

Hendon, *Feb.* 10, 1893.

THE ROCKS OF SOUTH DEVON.

Sir,—The issues raised by Professor Bonney's recent letters on the South Devon Rocks are so important and multifarious, that to deal with them adequately would require a far longer article than the limits of the Magazine could admit. For instance, without going further, I find in my copy of the Professor's original Devon paper (Q.J.G.S. vol. xl.), no less than 113 separate points noted and numbered for comment and criticism.

I hope on some future occasion to find both time and opportunity for a careful analysis and collation of several of Professor Bonney's papers, with especial reference to his position with regard to the Devonshire schists. In the meantime I venture to deprecate the constant introduction, by so distinguished a petrologist, of personalities, which are quite unworthy of a man of science, which are sure to revert upon himself, and which may even reflect indirectly on the British School of Petrology, of which for so many years Professor Bonney has been a prominent exponent.

Southwood, Torquay, 18*th February*, 1893. A. R. Hunt.

SCANDINAVIAN ROCKS IN THE ENGLISH BOULDER-CLAYS.

Sir,—In connection with the subject raised by Herr Madsen's recently published paper on "Scandinavian Boulders at Cromer,"[1] it may be of interest to give a list, brought up to date, of the Norwegian rocks which I have examined from the Boulder-clays of Holderness.

(i). Augite-syenite ('laurvikite' of Brögger) from the neighbourhood of Laurvig.
(ii). 'Rhombenporphyr' of Kjerulf and others, from the Christiania district.
(iii). 'Saussurite-gabbro,' as described by Möhl and Reusch from the west coast of Norway; two or three varieties.
(iv). A rather coarse red granite with much microcline and microperthite and subordinate dark mica. This agrees well with the rock described by Brögger from the Christiana district, but I have no specimens for comparison.
(v). Various grey granites with dark or with both dark and white micas, corresponding to those largely developed in the 'Grundfjeld' of Norway. These, unlike the preceding, always show cataclastic structures, strained quartz, etc.
(vi). Well-banded gneisses, the coarser ones hornblendic, the finer micaceous.
(vii). Various hornblende-schists and mica-schists, the latter often garnetiferous. These and the gneisses it would be impossible to refer to precise localities, but their Scandinavian origin cannot be doubted. Alfred Harker.

St. John's College, Cambridge.

Sir,—There is a curious error, which by some oversight has crept into my letter in the February Number of this Magazine. The sentence—"Creditably again is so variable a factor," etc. (which makes nonsense) should read "Credibility," as it stands in the rough MS. which I have by me. Most readers of the Geol. Mag. have probably made the correction fer themselves. A. Irving.

Wellington College, Berks, 4 *Feb.* 1893.

TITLES OF SEPARATE COPIES OF SCIENTIFIC PAPERS.

Sir,—A few years ago I advocated in your pages a reform in regard to the titles of separate copies of scientific papers: its adoption encourages me to venture further suggestions on the same lines in regard to the volumes themselves. My suggestions are:—

---

[1] Q.J.G.S. vol. xlix. p. 114, 1893.

that all papers should begin on a separate page; and that they should bear, as a heading, the full title of the publication in which they appear. My object is to facilitate work. I venture to say that it is a saving of time and temper for anyone, whether specialist or not, to have all their literature on any particular subject, or subdivision of a subject placed together: to attain this it is necessary to "break" publications, and to assort their papers. At present this too often entails the destruction of the preceding or succeeding paper—a matter for regret when only a limited number of copies is issued.

My suggestion would obviate this. I could wish it were applied to all publications in which original communications occur; but this, I fear, is Utopian. To the publications, however, of societies dealing with various sciences it is very necessary; to the publications of those dealing with one science it is quite as imperative, because subdivisions of a science are so numerous now. Very frequently the object desired could be attained by moving the first paper in the volume by one page; but in any case not one extra (blank) page per paper would be required. Expense, therefore, can hardly be urged against the proposal; while the boon conferred would be very great.

S. S. Buckman.

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—I have no desire to prolong this unprofitable controversy and must decline further argument with Sir H. Howorth, who still imagines he has completely proved his case, and who imputes to me words which I never employed. He takes up your space with discussing "authority" as if I had used the term, whereas my phrase was "the generally accepted views of geologists," or in other words what Sir Henry himself calls "the orthodox geological opinion."

With Dr. Hicks the case is different; but I think he should have known me better than to imagine I had the slightest idea of posing as an "official" or "professional" geologist. I used the term "practical," and by a *practical geologist* I mean anyone who has had experience in the work of mapping geological boundaries and collecting evidence for the construction of profile sections. By "approved work in the field" I mean work which stands the test of investigation by other geologists. I think Dr. Hicks will agree with me that a man who merely visits some well known sections in a faulted Palæozoic district is not entitled to criticize accepted views of its structure. Similarly in studying areas of Drift deposits it is often impossible to say whether a given patch of gravel is above or beneath Boulder-clay from a mere inspection of open sections, though their relations may become clear when the area is carefully mapped.

Is Dr. Hicks prepared to say, as Sir H. Howorth does, that there is no good ground for supposing the Hoxne deposits to be underlain by the neighbouring Boulder-clay? and in the face of Mr. Reid's statement in this Magazine (1888, p. 442), does he consider the superjacent patches of Boulder-clay to be in place? Unless he refuses credence to the observations of Messrs. Prestwich, H. B. Woodward, and C. Reid, he cannot support Sir H. Howorth.

I have confined myself to denying Sir Henry's contention that Mammoth-bearing deposits are "never underlain by Glacial Drift." I am perfectly prepared to admit that Mammoth-remains do occur under undoubted Glacial deposits, as Dr. Hicks maintains, but that is not the point in question. A. J. Jukes-Browne.

Exeter, *Feb.* 7, 1893.

A BORING AT WILLOUGHBY IN LINCOLNSHIRE.

Sir,—I think you will find that the boring at Willoughby, mentioned in the paragraph quoted from the "Morning Post" in the Geological Magazine for February, was made in 1887. I have some particulars of the strata passed through which I hope to publish shortly, and will only now say that it supplies valuable information about the subterranean structure of that part of Lincolnshire. The boring passed directly from Glacial Drift into the so-called Neocomian, without the intervention of any kind of Chalk. Water was found at the top of the Spilsby Sandstone.

Exeter, *Feb.* 7. A. J. Jukes-Browne.

SUBTERRANEAN EROSION.

Sir,—In the Geological Magazine for September, 1892, Mr. Morton, F.G.S., criticised a paper I read in December, 1891, before the Geological Society, entitled "The Subterranean Erosion of the Glacial Drift, a probable cause of Submerged Peat and Forest Beds" (Quart. Journ. Feb. 1892, pp. 96–103). So far as Mr. Morton's criticisms partake of the nature of a defence of his theory of the origin of the submerged Peat and Forest-beds of Lancashire and Cheshire as described in his work entitled "The Geology of the Country around Liverpool" I do not propose to discuss, for if Mr. Morton's theory be right then my theory must be wrong, and *vice versa.*

Mr. Morton's remarks, however, go beyond the mere local application of the principle of subterranean erosion. In concluding, he writes, "It is very remarkable that such an active agent has not been observed in Tertiary formations of the South of England where the beds of clay and sand are similar and occur under the same conditions." I go further even than Mr. Morton, viz.—If the principle of Subterranean Erosion be true at all it will prove as true in the past as in the present (under the conditions mentioned) and as wide in its operations as the law of gravitation. In the Quart. Journ. of the Geol. Soc. vol. xlviii. p. 103, I defined Subterranean Erosion as follows :—

"That *wherever* water percolated through such unconsolidated beds as clays, sands, and gravels, *along an inclined plane,* it was constantly carrying the lighter materials of such strata towards the *nearest point of escape. The nearer the approach to the point of escape,* the *greater* became the *power of subterranean erosion.* This action caused *lateral subsidence.*"

I maintain (*inter alia*) this "principle of geology" may be responsible for such widely separated events as the Submerged Peat and Forest-beds of the Estuary of the Thames, the swamps of America, the Contorted Drifts of Norfolk, and the "thick coals" of South Staffordshire. WILLIAM SHONE.

UPTON PARK, CHESTER, *Dec.* 18, 1892.

OBITUARY.

PROFESSOR JOHN O. WESTWOOD, M.A., F.L.S., &c.

HON. PRESIDENT ENTOMOLOGICAL SOCIETY OF LONDON;
HOPE PROFESSOR OF ZOOLOGY IN THE UNIVERSITY OF OXFORD.

BORN 1805. DIED 2 JANUARY, 1893.

ANOTHER venerable Professor has passed away in the opening of the New Year. John Obadiah Westwood was the son of the late Mr. Westwood, of Sheffield, and was born in that town in the year 1805. Having been privately educated at Lichfield, he shortly after commenced active life and migrated to London, where he early displayed an ardent love of Entomology. He was one of the original members of the Entomological Society of London, founded in 1834, and after being twice President, was elected honorary life President. His "Introduction to the Modern Classification of Insects" and the "Entomologist's Text-Book" appeared in 1838; his "British Butterflies and their Transformations," in 1841; "Arcana Entomologica"; "British Moths and their Transformations," &c. in 1845; "Cabinet of Oriental Entomology," in 1848; Descriptions of Fossil Insects in the Rev. P. B. Brodie's "History of the Fossil Insects in the Secondary Rocks of England" (London 1845 with 11 plates), and a valuable paper on Purbeck Insects (Quart. Journ. Geol. Soc., Vol. ix. pp. 378–396, 1854).

In 1855 the Royal Society presented him with one of the Royal Medals in recognition of his valuable contributions to Entomology.

In 1861 Mr. Westwood was appointed to the professorship of Zoology in the University of Oxford, then newly founded by the munificence of the late Rev. F. W. Hope. Soon afterwards the Professor was made an Honorary Fellow of Magdalen College, Oxford. Professor Westwood was joint author with Mr. C. Spence-Bate, of a "History of the British Sessile-eyed Crustacea" (2 vols., 1863–1868). He was a Fellow of the Linnæan Society for nearly 70 years, and was an Honorary or Corresponding Member of the Entomological and Zoological Societies of Paris, Holland, Belgium, Berlin, Stettin, Munich, Vienna, Stockholm, St. Petersburg, Moscow, Quebec, Boston (U.S.A.), and many other Societies. His separate papers are too numerous to quote here. As a draughtsman of Insects he was highly skilled. He continued his lectures at Oxford till a very recent date, and his loss is deeply regretted in the University.

MARTIN SIMPSON.

BORN 20TH NOVEMBER, 1798. DIED 31ST DECEMBER, 1892.

THE death of Mr. SIMPSON, of Whitby, severs the remaining link with "Young and Bird," and takes us back to an age when geology was quite in its infancy. Mr. Simpson served his apprenticeship to a cabinet maker in Whitby, and afterwards entered as a student at Edinburgh University. In 1836 he became second master at Wakefield Grammar School, and frequently lectured on geology in that neighbourhood. His active geological life was almost entirely spent in his native district, and it may be said that for over half a century he investigated the rocks and collected the fossils of the Whitby area. Most of his wanderings were made on foot, and the results of his labours were published in his "Monograph of the Ammonites of the Yorkshire Lias" (1843); The Fossils of the Yorkshire Lias (1855); A Guide to the Geology of the Yorkshire Coast (1859); and the Geology of Whitby (1861). Acting as Honorary Curator of the Whitby Museum he became well-known to geologists from all parts of the world, and it was not through any want of labour on his part that the Museum (so full of types) did not take rank as one of the best in the kingdom. In 1860 the Council granted him the magnificent remuneration of £10 per annum, which he received till his death. Fortunately, however, a small farm which he possessed brought him in sufficient for his daily needs, but he was preeminently one who *laboured* for science, and for the credit of his town, *without reward.*

His familiar figure, and unvarying old-world courtesy, will long be remembered by those who had the fortune to come in contact with him, and though his work may have now passed out of date, the energy he displayed and the difficulties he had to contend with, must always demand our admiration and respect. C. D. S.

MISCELLANEOUS.

MALTESE CAVE-EXPLORATION.—Mr. JOHN H. COOKE, F.G.S., has just (Feb. 23) submitted his Report to the Royal Society of London, on the exploration of the Har-Dalam Cave, Malta. Mr. Cooke has been fortunate in adding a Bear (related to *Ursus ferox*), and the "Barbary Deer" (*Cervus elaphus*, var. *barbarus*) to the fauna of the Maltese caves. He also found the pigmy Hippopotamus (*H. Pentlandi*) in great abundance. This species is common in Sicily and adjacent lands. Man is represented from this cave by a single metacarpal bone, and by pottery of two distinct periods, of Phœnician and Punic origin. The antiquity of the cave and its deposits is proved by the fact that the cave is now 40 feet above the level of the gorge, whose flood-waters freely flowed into it in prehistoric times. At present only a tiny streamlet (dry, save in the rainy-season) flows through the gorge, incapable of performing any visible erosion, whereas the ancient stream carried large boulders along its course and piled them also (well water-worn and rounded) in abundance within the cavern, which is some 400 feet in length. Only one molar and part of a jaw and one humerus of *Elephas mnaidriensis* were found.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. IV.—APRIL, 1893.

ORIGINAL ARTICLES.

I.—Notes on the Devonian Fishes of Campbelltown and Scaumenac Bay in Canada.—No. 2.[1]

By R. H. Traquair, M.D., F.R.S., F.G.S.

MR. DAMON of Weymouth having recently received a third consignment of fossil fishes and Fish-remains from the Devonian Rocks of Canada, an interesting selection has been made for the Edinburgh Museum, and I am thus enabled to contribute some additional notes regarding the palæozoic ichthyology of this region. The specimens were, as before, collected by Mr. Jex.

Fishes from the Lower Devonian of Campbelltown.

Protodus Jexi, A. S. Woodward.

Geol. Mag. Dec. III. Vol. IX. 1892, pp. 1–2, Pl. I. Figs. 1, 1*a*.

A great many specimens of this tooth have been last summer collected by Mr. Jex. That it is a selachian tooth is proved beyond doubt, not merely by its shape, but by its occasionally occurring in transverse bands, three or four being in apposition in a row back to front.

Doliodus problematicus (A. S. Woodward).

Diplodus problematicus, A. S. Woodward, *op. cit.* p. 2, Pl. I. Fig 2.

Only a single specimen of this curious tooth was at Mr. Smith Woodward's disposal, and that too only exhibiting the crown and denticles, being destitute of the root. The cusps certainly resemble those of *Diplodus* in form and arrangement, but the peculiar form of the base, which is well shown in many of the specimens now before me, is very different, and necessitates the institution of a new genus, which, on account of the deceptive appearance of the first described example, I propose to name *Doliodus*.[2]

Instead of the thick solid base of *Diplodus* we have here a broad thin plate, convex anteriorily and above, concave posteriorly and below, to the upper margin of which the crown is attached. The type specimen has only one intermediate cusp, but their number may vary from one to three or even four.

In connection with the generic separation of this form of tooth from *Diplodus*, Ag., it is interesting to observe that although during his last visit to Canada, Mr. Jex obtained a large number of these teeth, not one example of a Pleuracanth spine has occurred in the same beds. I therefore doubt its being even referable to the family Pleuracanthidæ.

---

[1] For No. 1 see Geol. Mag. Dec. III. Vol. VII. 1890, pp. 15–22.

[2] Gr. Δόλιος a deceiver.

? *Cheiracanthus costellatus*, sp. nov.

Several detached spines and one fish wanting the head constitute the remains of this interesting species, which are contained in the present collection.

The fish measures four inches in length, but it is so distorted and shortened up that its real dimensions and contour cannot be determined. Six spines are shown, which I interpret as two pectoral, two ventral, one dorsal, and one anal. The spines are large and rather slender; the pectoral measuring $1\frac{3}{8}$ inch in length and $\frac{1}{8}$ inch in breadth about the middle, the dorsal $2\frac{1}{8}$ inches. The others are imperfect, but all are remarkably straight save the pectoral, which is gently curved. The exposed surface of the spines is marked by prominent longitudinal ridges and furrows, there being four to six on each side, while the median one along the anterior aspect of the spine is broader than the others. There are two clavicular elements near the pectoral spines which resemble in form rather more those of *Cheiracanthus* than of *Acanthodes.* The scales are marked on their exposed surfaces with extremely fine striæ, which are only visible under a strong lens, and pass longitudinally across the scale in a direction parallel to the diagonal, connecting the anterior and posterior angles.

On first seeing the spines I thought of Whiteaves's *Homacanthus gracilis* from the same beds; but they are more slender and have less of a "conical" shape than the spine figured by that author; besides which there are no signs of posterior denticles. It is unfortunate that the fish is so distorted that the relative position of the spines, and especially of the dorsal, with regard to the anal is obscured, so that its reference to *Cheiracanthus* must of course be considered as merely provisional; indeed against this reference may be mentioned the fact that, in their strongly fluted character, the spines rather deviate from those of the well known Scottish species *Ch. Murchisoni* and *Ch. latus.*

Cephalaspis Campbelltownensis, Whiteaves.

Whiteaves, Canadian Nat. n.s. vol. x. p. 98; and Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 92, pl. x. fig.

In my former paper I recognized two distinct species of *Cephalaspis* from the Campbelltown beds, one having the cephalic shield rounded in front, the other in which it assumed a pointed form like the snout of a skate. Mislead by Mr. Whiteaves's figure, I referred the former to his *C. Campbelltownensis*; to the latter I attached the name of *C. Whiteavesi.*

Mr. Smith Woodward having had subsequently the privilege of inspecting the original type of *C. Campbelltownensis*, found that it actually possessed the pointed rostrum characteristic of my *C. Whiteavesi*, which rostrum had been omitted in the drawing published by Mr. Whiteaves.[1] Consequently my species had to go, though it was clear that there was something still to be determined regarding the species of *Cephalaspis* occurring at Campbelltown.

---

[1] A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. ii. p. 191.

The mystery is quite cleared up by the specimens in the present collection; there *are* two species, but the new one is that with the *rounded* snout, which I shall describe under the name of

Cephalaspis Jexi, sp. nov.

Cephalic shield rounded in front, cornua incurved, comparatively short and stout; the orbits relatively smaller than in *C. Campbelltownensis,* situated nearly midway between the anterior and posterior extremities of the shield. The external ornament of the shield consists of minute closely set tubercles often tending to be arranged in concentric lines which are parallel to the borders of the tesserae. On the cornua the tubercles are not so close, showing intervals which are finely longitudinally striated. The inner margins of the cornua are distinctly denticulated.

In *C. Campbelltownensis,* on the other hand, the front of the shield is produced into a pointed rostrum, the cornua are relatively longer, the orbits relatively larger than in the preceding species. The ornamentation of the cornua and the denticulation of their inner margins is more delicate, the former consisting of minute pits and reticulating furrows, the interspaces between which appear as minute flattened tubercles.

Both of these species seem to be common at Campbelltown, but perfect shields of *C. Jexi* are rare, being mostly broken on one side, or else distorted by pressure; whereas those of *C. Campbelltownensis* more commonly retain their contour complete. As the name *Whiteavesi,* having dropped, cannot according to the rules of nomenclature be again applied to a different species of *Cephalaspis,* I have pleasure in dedicating this new one to Mr. Jex.

Phlyctænaspis Acadica, Whiteaves.

Coccosteus Acadicus, Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 93, pl. ix. and woodcut.

Phlyctænaspis Acadica, Traquair, Geol. Mag. Dec. III. Vol. VII. pp. 20 and 60, Pl. III. Figs. 1, 2.

Phlyctænaspis acadica, A. S. Woodward, Cat. Foss. Fishes, British Museum, pt. ii. p. 295. Also in Geol. Mag. Dec. III. Vol. VIII. 1891, p. 5.

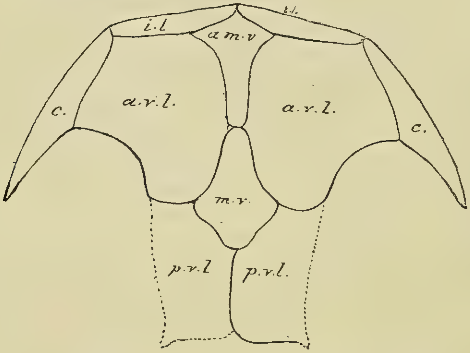
This collection is rich in remains of *Phlyctænaspis Acadica,* among which are some specimens which throw fresh light upon the structure of this interesting and still imperfectly known genus.

One of them shows a large portion of the ventral shield with nearly all its plates *in situ,* and from it, along with detached plates, I have drawn the accompanying restoration, which clears up, I think, certain important points recently discussed by Mr. Smith Woodward.

This specimen shows the left anterior ventro-lateral plate and part of the right one, also the median ventral plate and the greater part of the posterior ventro-lateral plate of the left side, and finally the left lateral spine or cornu in connection with the corresponding anterior ventro-lateral.

The anterior median ventral is not here exhibited, but as it occur detached in another specimen I have in the figure inserted it in its place. The median ventral is however well shown in position, and detached examples of it occur showing both outer and inner aspects. Both of these median plates closely resemble the corresponding plates in *Coccosteus*.

So does the anterior ventro-lateral (*a. v. l.*) which is quite correctly identified by Whiteaves (*op. cit.* pl. ix. fig. 3). Now attached to the antero-external margin of this plate is seen the spine-like body recently described by Mr. Smith Woodward. This spine occurs not only in the specimen on which the above restored sketch is founded, but in the collection now before me is found both absolutely detached, and also in articulation with otherwise isolated examples of the anterior ventro-lateral plate.



Phlyctænaspis Acadica, Whiteaves; restoration of ventral carapace. *a.v.l.* anterior ventro-lateral plates; *p.v.l.* posterior ventro-lateral, not defined in the outer margin in the fossil; *a.m.v.* anterior median ventral; *m.v.* median ventral; *i.l.* interlateral; *c.* cornu or lateral spine.

Mr. Woodward mentions these spines as "each apposed to a lateral plate of the trunk:" it is now shown to *which* lateral plate, as well as to which part of the dermal armour of *Coccosteus*, they correspond.

It will be seen that the spine (*c*) touches with its proximal extremity a narrow portion of bone (*i. l.*) which is articulated with the anterior margin of the anterior ventro-lateral plate (*a. v. l.*). On turning to my previous restoration of the ventral cuirass of *Coccosteus decipiens*, Ag.[1] it will at once be seen that this portion of bone corresponds exactly to the anterior-inferior part of the interlateral plate, (*i. l.*) which occupies the same position with regard to the anterior ventro-lateral, and meets its fellow of the opposite side in front of the anterior median ventral (*a. m. v.*) while the spine in like manner corresponds to the short process which passes backwards separating the anterior ventro-lateral below from the antero-lateral above. This process, short in *C. decipiens*, is more largely developed in *C. minor*, H. Miller, in which species I have stated that it has a "very spine-like appearance," though owing to the proportionally greater extent of the margins of the antero-lateral and anterior ventro-lateral plates with which it articulates, it forms no more of an independent projection than in the former.[1] But as in *Phlyctænaspis* this spine seems divided by a very distinct suture from the interlateral plate, I have carefully examined the suite of specimens, both of *Coccosteus decipiens* and *C. minor* in the Edinburgh Museum, with the result that I have convinced myself that the process in question is here also a distinct element, to which the name of "lateral spine" may appropriately be given. In both genera it is immovably fixed; in one example of *Phlyctænaspis* it seems indeed anchylosed to the interlateral plate.

---

[1] Ann. and Mag. Nat. Hist (6) vol. v. 1890, pl. x. fig. 3.

Consideration of this element of the cuirass of the Coccosteidæ calls up of course the question of *Acanthaspis*, Newberry. Mr. Smith Woodward[2] remarks that the spines of *Phlyctænaspis* "are indeed precisely similar in external form and appearance to those of *Acanthaspis*; and so far as can be judged from known specimens they only differ from the last-mentioned spines, in the circumstance that the supporting plate is destitute of the extended oblique pedicle observed both in the type specimens from the Corniferous Limestone of Ohio, and in the shield assigned to the same genus from Spitzbergen. It thus remains to discover more associated examples of the plates and spines from Ohio, to determine whether they actually pertain to Ostracoderms, as suspected, or whether they represent part of the armour characteristic of Arthrodira; for the fixed spinous appendage is now proved to occur in both of these widely separated groups."

It will be remembered that Mr. Woodward, in a previous paper,[3] was inclined to consider *Acanthaspis* as being "most nearly related to the Asterolepidæ, and its spine-like processes to be the homologue of the well-known pectoral-paddles of the latter." But a comparison of Newberry's figures with the sketch of the ventral cuirass of *Phlyctænaspis* given above will remove all doubt as to the Coccostean character of the remains from the Corniferous Limestone of Ohio; figures 1, 2, 3, and 4 on plate lv. of Prof. Newberry's work[4] representing obviously the lateral spine in conjunction with the anterior ventro-lateral plate of a creature allied to the Canadian genus, though the supporting plate is remarkably short from before backwards. The same view must, I think, be adopted for Mr. Woodward's *Acanthaspis decipiens* from Spitzbergen, so that I cannot consider the occurrence of a fixed spinous appendage to be as yet proved in any genus specially allied to the Asterolepidæ. Whether this fixed spine is in any way homologous to the articulated appendage of Asterolepidæ, or to the pectoral limb of vertebrates in general, I need not at present discuss.

Associated with other plates of *Phlyctænaspis Acadica*, are several fragments of dentigerous bones, showing small, smooth-pointed conical teeth in one row.

[1] R. H. Traquair (Geol. Mag. Dec. III. Vol. VI. Pl. I. Fig. 3.

[2] *Op. cit.* p. 481.

[3] "Devonian Fish-Fauna of Spitzbergen," Ann. and Mag. Nat. Hist. (6) vol. viii. pp. 1–15.

[4] Geol. Survey of Ohio, Palæontology, vol. ii.

II.—RESTORATIONS OF *ANCHISAURUS*, *CERATOSAURUS*, AND *CLAOSAURUS*.

By Professor O. C. MARSH, M.A., Ph.D., LL.D., F.G.S.

(PLATES VI. & VII.)

A NUMBER of restorations of dinosaurian reptiles have been recently made by the writer, based upon American specimens which he has personally investigated. Reduced figures of three of these restorations have already appeared in this MAGAZINE; namely, *Brontosaurus* and *Stegosaurus* from the Jurassic, and *Triceratops* from the Cretaceous. Three others of interest are given in the present Number; *Anchisaurus* from the Triassic, *Ceratosaurus* from the Jurassic, and *Claosaurus* from the Cretaceous. The last is a gigantic herbivorous reptile, a typical member of the *Ornithopoda*, and one of the American allies of *Iguanodon*. The other two are carnivorous forms of the order *Theropoda*, as defined by the writer. *Ceratosaurus* has apparently its nearest European ally in *Megalosaurus*, while *Anchisaurus* appears most nearly related to *Thecodontosaurus*.

The three restorations here represented are each based upon the remains of a single individual, which were nearly or quite complete when found, and apparently in the position in which each animal died. The skull and the greater part of each skeleton were secured, and the portions lost are represented in allied

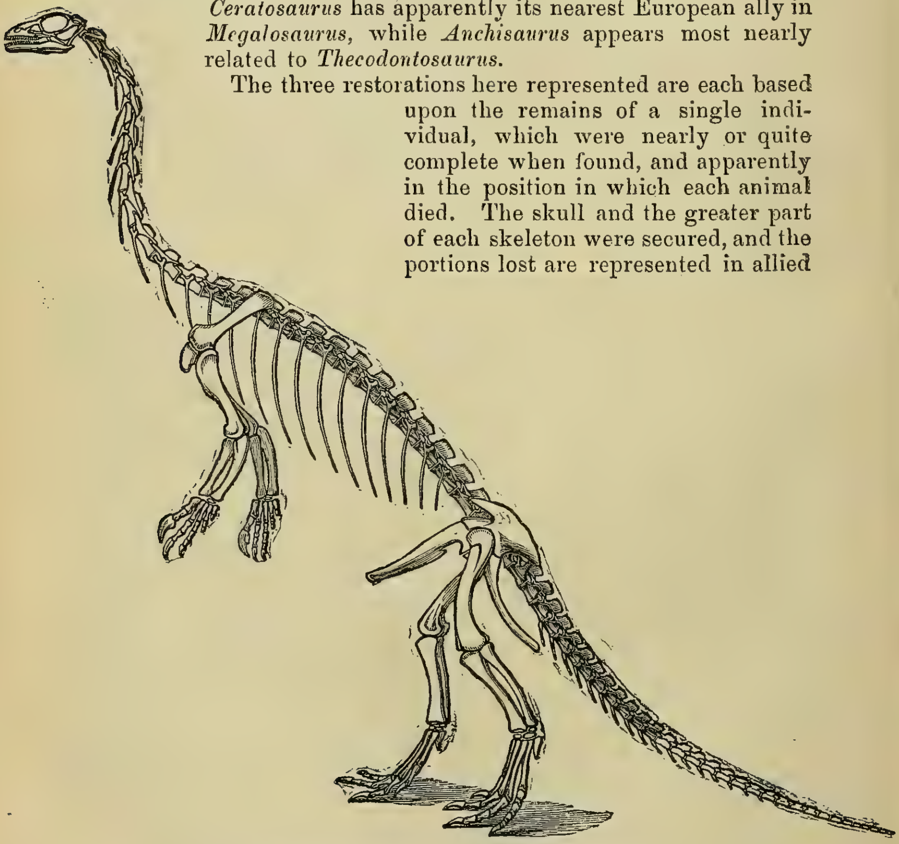


FIG. 1.—*Anchisaurus colurus*, Marsh. $\frac{1}{12}$ nat. size.
From the Upper Triassic Sandstone, Connecticut, U.S.A.

forms from the same localities, so that the chances of error in the restorations has been much reduced. The type specimens themselves have been fully described by the writer in the "American Journal of Science."

Restoration of Anchisaurus.

The Triassic dinosaurs now known from the Connecticut river sandstone have been investigated by the writer, and some of the results have already been placed on record.[1] Remains of five individuals have been discovered, sufficiently well preserved to indicate the main characters of the animals to which they pertained. These were all carnivorous forms of moderate size, and the known remains are from essentially the same geological horizon. Many larger forms, probably herbivorous, are indicated by footprints, but no characteristic portions of the skeleton have yet been found.

The genus *Anchisaurus*, one of the oldest known members of the *Theropoda*, is so well represented by parts of four skeletons, two nearly complete, from these deposits, that a restoration of one species can now be made with considerable certainty. This has been attempted, and the result is given, one-twelfth natural size, in the above figure (Fig. 1). The animal when alive was about six feet in length.

The skeleton chosen for this restoration is the type specimen of *Anchisaurus colurus*, already described by the writer. This skeleton when discovered was apparently entire. Portions of the neck and the tail vertebræ were unfortunately lost before the importance of the specimen was realized, but the skull, and nearly all the rest of the skeleton, were saved. From these the matrix in great part has been removed, so that the more important characters can be made out with certainty. The parts missing are fortunately preserved in a smaller specimen of an allied species (*Anchisaurus solus*) found at the same locality, and these have been used to complete the outline of the restoration. Portions of two other specimens, nearly allied, and from the same horizon, were also available, and furnished some suggestions of value.

The restoration as shown in Fig. 1. indicates that *Anchisaurus colurus* was one of the most slender and delicate dinosaurs yet discovered, being only surpassed in this respect by some of the smaller bird-like forms of the Jurassic. The position chosen is one that must have been habitually assumed by the animal during life, but the comparatively large fore limbs suggest the possibility of motion on all four feet. The compressed terminal digits of the fore feet, however, must have been covered by very sharp claws, which were used mainly for prehension, and not for locomotion.

The small head and bird-like neck are especially noticeable. The ribs of the neck and trunk are very slender. The tail apparently differed from that of any other dinosaur hitherto described, as it was evidently quite slender and flexible. The short neural spines and the diminutive chevrons directed backward indicate a tail not compressed, but nearly round, and one usually carried free from the ground.

---

[1] American Journal of Science, vol. xxxvii. p. 331, April, 1889; vol. xlii. p. 267, September, 1891; and vol. xliii. p. 543, June, 1892; see also vol. xlv. p. 171, February, 1893.

The type specimen of *Anchisaurus*, here restored, was found in Connecticut, in the upper portion of the Triassic sandstone. The associated fossils were carnivorous dinosaurs and plants.

The present restoration will tend to clear up one point long in doubt. The so-called "bird-tracks" of the Connecticut river sandstone have been a fruitful subject of discussion for half a century or more. That some of these were not made by birds has already been clearly demonstrated by finding with them the impressions of fore feet, similar to those made by reptiles. Although no osseous remains were found with them, others have been regarded as footprints of birds, because it was supposed that birds alone could make such series of bipedal, three-toed tracks, and leave no impression of a tail.

It is now evident, however, that a dinosaurian reptile like *Anchisaurus* and its near allies must have made footprints very similar to, if not identical with, the "bird tracks" of this horizon. On a firm but moist beach, only three-toed impressions would have been left by the hind feet, and the tail could have been kept free from the ground. On a soft, muddy shore, the claw of the first digit of the hind foot would have left its mark, and perhaps the tail also would have touched the ground. Such additional impressions the writer has observed in various series of typical "bird tracks" in the Connecticut sandstone, and all of them were probably made by dinosaurian reptiles. No tracks of true birds are known in this horizon.

Restoration of Ceratosaurus.. (Plate VI.)

In the same horizon of the Jurassic in which *Brontosaurus* and *Stegosaurus* were found, the skeleton restored in Plate VI. was likewise discovered. It pertained to a typical carnivorous dinosaur of medium size, which doubtless was one of the various enemies of the large herbivorous forms. The restoration represents the reptile one-thirtieth natural size, and in a position it must have frequently assumed in life. The type-specimen on which this restoration is based has already been described by the writer.[1]

The skull of *Ceratosaurus* is very large in proportion to the rest of the skeleton. The posterior region is elevated, and moderately expanded transversely. The facial portion is elongate, and tapers gradually to the muzzle. Seen from above, the skull resembles in general outline that of a crocodile. The nasal openings are separate and lateral, and are placed near the end of the snout, as shown in Plate VI.

Seen from the side, this skull appears lacertilian in type, the general structure being light and open. From this point of view, one special feature is the large, elevated, trenchant horn-core situated on the nasals. Another feature is the large openings on the side of the skull, four in number. The first of these is the anterior nasal orifice; the second, the triangular antorbital foramen; the third, the large oval orbit; and the fourth, the still larger lower temporal opening.

---

[1] American Journal of Science, vol. xxvii. p. 329, April, 1884; vol. xxviii. p. 161, August, 1884; and vol. xliv. p. 347, October, 1892.

The parietal bones are of moderate size, and there is no parietal foramen. The frontal bones are rather short, and are closely united on the median line. The nasal bones are more elongate than the frontals, and are firmly coössified. These bones support the compressed, elevated horn-core on the median line. The lateral surface of this elevation is very rugose, and furrowed with vascular grooves. It evidently supported a high trenchant horn, which must have formed a most powerful weapon for offence and defence.

The premaxillaries are separate, and each contained three functional teeth. The maxillary bones are large and massive, as shown in Plate VI. They are provided each with fifteen functional teeth, which are large, powerful, and trenchant, indicating the ferocious character of the animal when alive. These teeth have the same general form as those of *Megalosaurus*, and the dental succession appears to be quite the same. Above the antorbital foramen on either side is a high elevation composed of the prefrontal bones. These protuberances would be of service in protecting the orbit, which they partially overhang.

The lower jaws of *Ceratosaurus* are large and powerful, especially in the posterior part. In front, the rami are much compressed, and they were joined together by cartilage only. There were fifteen teeth in each ramus, similar in form to those of the upper jaws.

The cervical vertebræ of *Ceratosaurus* differ in type from those in any other known reptiles. With the exception of the atlas, all are strongly opisthocœlian, the cup on the posterior end of each centrum being unusually deep. In place of an equally developed ball on the anterior end, there is a flat surface. The size of the latter is such that it can only be inserted a short distance in the adjoining cup. This peculiar articulation leaves more than three-fourths of the cup unoccupied by the succeeding vertebra, forming, apparently, a weak joint.

The dorsal and lumbar vertebræ are bi-concave, with only moderate concavities. The sides and lower surface of the centra are deeply excavated, except at the ends. All the pre-sacral vertebræ are very hollow, and this is also true of the anterior caudals.

There are five well-coössified vertebræ in the sacrum of the present specimen of *Ceratosaurus nasicornis*. The transverse processes are very short, each supported by two vertebræ, and they do not meet at their distal ends. The caudal vertebræ are bi-concave. All the anterior caudals, except the first, supported very long chevrons, indicating a high, thin tail, well adapted to swimming. The tail was quite long, and the distal caudals were very short.

The scapular arch of *Ceratosaurus* is of moderate size, but the fore limbs are very small. The humerus is short, with a strong radial crest. The radius and ulna are also very short, and nearly equal in size. The carpal bones were only imperfectly ossified. There were four digits in the fore foot, and all were armed with sharp claws. The second and third digits were much larger than the first and fourth, and the fifth was entirely wanting.

The pelvic arch of *Ceratosaurus* is of special interest. In the type specimen here restored, the ilium, ischium, and pubis, on each side, are firmly coössified. The ilia, moreover, are attached to the sacrum, which was in place in the skeleton. The ilia have the same general form as in *Megalosaurus*. The ischia are comparatively slender. They project well backward, and for the last half of their length the two are in close apposition. Their distal ends are coössified and expanded, as shown in Plate VI.

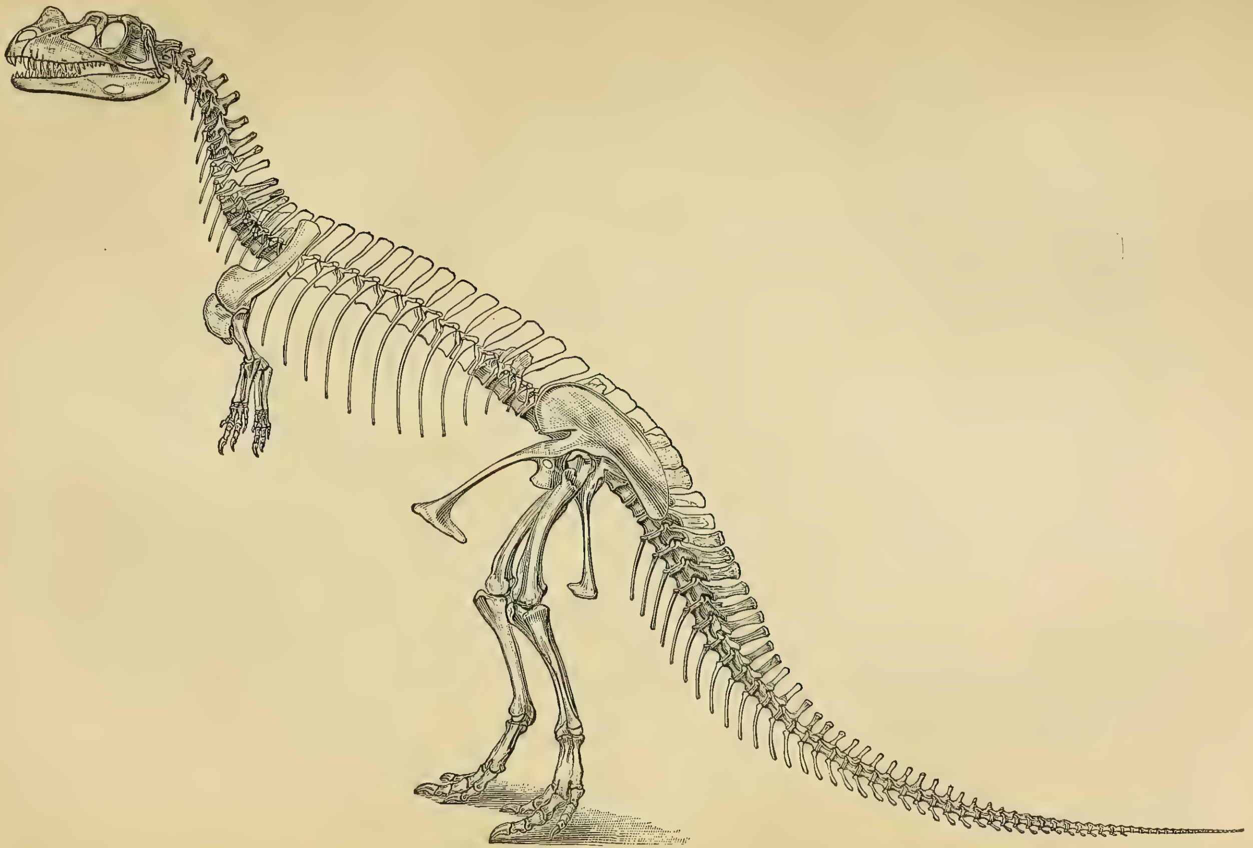
The pubes have their distal ends coössified, and expand into an elongate, massive foot, which is one of the most characteristic parts of the skeleton. It is probable that this foot in connection with the distal ends of the ischia served to support the body in sitting down. That some Triassic dinosaurs sat down on their ischia is proved conclusively by the impressions in the Connecticut river sandstone. In such cases, the leg was bent so as to bring the heel to the ground. The same action in the present reptile would bring the foot of the pubes to the ground, nearly or quite under the centre of gravity of the animal. The legs and ischia would then naturally aid in keeping the body balanced. Possibly this position was assumed habitually by these ferocious biped reptiles, in lying in wait for their prey.

The femur is much curved, and the shaft very hollow. The tibia is shorter than the femur, nearly straight, and has a large cnemial crest. The astragalus is not coössified with the tibia, and has a strong ascending process. The fibula is well developed, and nearly straight, its distal end fitting into the calcaneum. The tarsals of the second row are very thin, and united to the metatarsals below them.

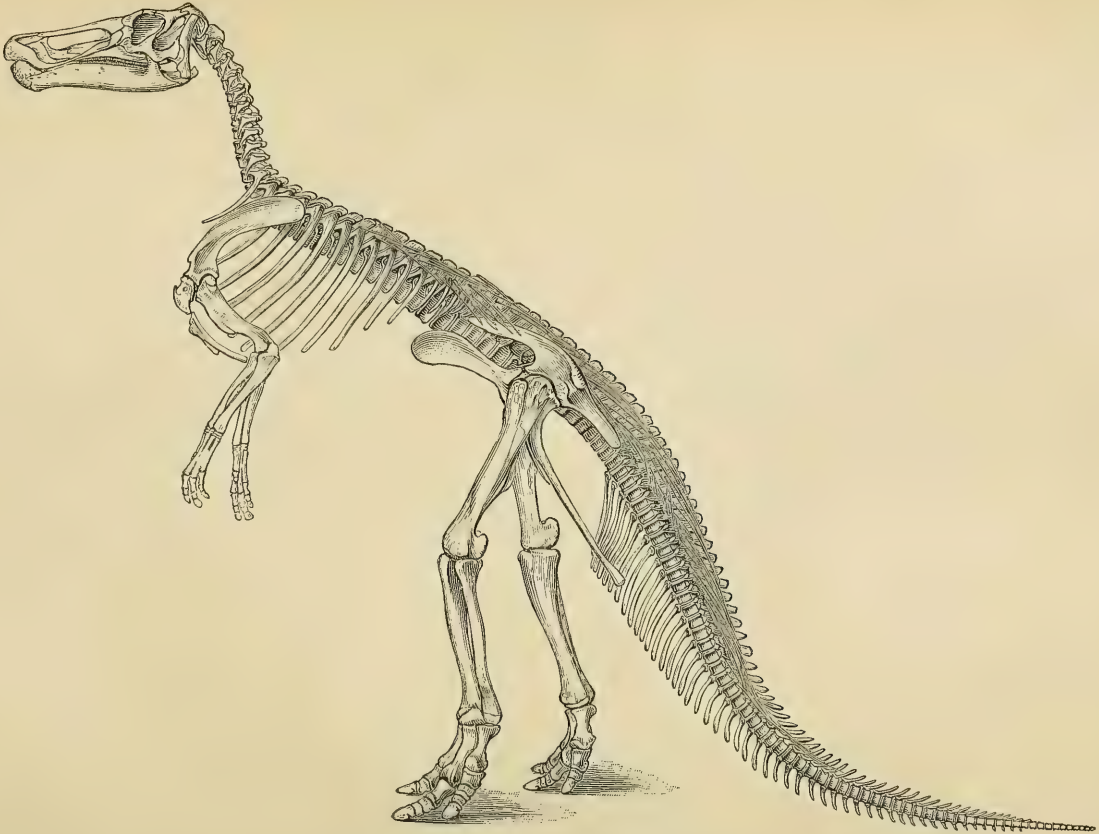
The most interesting feature in the extremities of this dinosaur is in the metatarsal bones, which are completely ankylosed, as are the bones of the pelvis. There are only three metatarsal elements in each foot, the first and fifth having apparently disappeared entirely. The three metatarsals remaining, which are the second, third, and fourth, are proportionally shorter and more robust than in the other known members of the *Theropoda*, and being firmly united to each other, they furnish the basis for a very strong hind foot. The phalanges of the hind feet are of moderate length, and most of them are quite hollow. The terminal phalanges evidently supported strong and sharp claws.

The unique cervical vertebræ, the coössification of the pelvic bones, and the union of the metatarsals, as in modern birds, distinguish *Ceratosaurus* widely from all other dinosaurs, and make it the type of a well-marked family, the *Ceratosauridæ*. The nearest allied form is apparently *Ornithomimus*, from the Laramie, recently described by the writer.

The type specimen of *Ceratosaurus* was about twenty-two feet long when alive, and twelve feet high as here restored. It was



Ceratosaurus nasicornis, Marsh. $\frac{1}{30}$ nat. size.
UPPER JURASSIC, COLORADO.



Claosaurus annectens, Marsh. $\frac{1}{40}$ nat. size.
LARAMIE (CRETACEOUS) FORMATION, WYOMING.

found in the upper Jurassic of Colorado. The associated fossils were mainly other dinosaurs, especially *Sauropoda* and *Ornithopoda*, together with various small mammals.

Restoration of Claosaurus. (Plate VII.)

The most interesting feature in the restoration of *Claosaurus* given on Plate VII. is the skull, which has been fully described by the writer elsewhere,[1] but its main features may be noticed here. This skull is long and narrow, with the facial portion especially produced. The anterior part is only moderately expanded transversely, thus differing from that of *Hadrosaurus*, a nearly allied form. Seen from the side, the skull of *Claosaurus* shows a blunt, rugose muzzle, formed above by the premaxillary, and below by the predentary, both probably covered in life with a thick corneous integument.

Behind the upper part of this muzzle is an enormous lateral cavity, which includes the narial orifice, but was evidently occupied in life mainly by a nasal gland, somewhat like that in the existing Monitor, and also seen in some Birds. This cavity is bounded externally by the nasal bone and the premaxillary. The orbit is very large, and subtriangular in outline. It is formed above by the prefrontal, frontal, and postfrontal, and below mainly by the jugal. There are no supra-orbital bones. A distinct lachrymal forms a portion of the anterior border. The infra-temporal fossa is large, and bounded below by the jugal. There is a thin quadrato-jugal between the jugal and quadrate. The occipital condyle is directed backward and downward.

The nasals are very long and slender, and in front are separated by the narrow superior processes of the premaxillaries. The frontals are short and broad, and somewhat concave above. The parietals are firmly coössified, and very small, forming a thin partition between the supra-temporal fossæ. The latter are bounded posteriorly by the massive squamosals, which contain a deep cavity for the head of the quadrate, and also overlap the exoccipitals.

The striking features of the lower jaw are the massive rugose predentary, the large and powerful dentary bone with its robust coronoid process, and the very small angular and articular bones.

The teeth are confined entirely to the maxillary and dentary bones. They closely resemble those of *Hadrosaurus*, are arranged in the same manner, and appear to be equally numerous. They were well adapted to a diet of soft succulent vegetation.

The main characters of the vertebral column of *Claosaurus* are shown in the restoration. There are thirty vertebræ between the skull and sacrum, nine in the sacrum, and about sixty in the tail. The whole vertebral column was found in position except the terminal caudals, which are here represented in outline. The cervical vertebræ are strongly opisthocœlian, and the first eleven have short ribs. The dorsals are also opisthocœlian. There are no true lumbar vertebræ, as the last of those in front of the sacrum support free ribs. The first and second caudals have no chevrons. Behind these, thec hevron bones are very long, indicating a powerful compressed tail, well adapted for swimming.

---

[1] American Journal of Science, vol. xxxix. p. 423, May, 1890; vol. xliii. p. 453, May, 1892; vol. xliv. p. 171, August, 1892; and vol. xliv. p. 344, October, 1892.

In the median dorsal region, between the ribs and the neural spines, are numerous rod-like ossified tendons, which increase in number in the sacral region and along the base of the tail, and then gradually diminish in number and size, ending at about the thirty-fifth caudal. These ossified tendons are well shown in the restoration, and are of much interest. They are not unlike those in *Iguanodon* described by Dollo, but as a rule are more elongate, and appear to lack the definite arrangement in rhomboidal figures observed in that genus.

The fore limbs are unusually small in comparison with the posterior, and the relative size of the two is shown in the restoration. The scapular arch presents many points of interest. The scapular is large, and much curved. On the anterior margin, above the articulation for the coracoid, is a strong protuberance, with a well-defined facet, adapted to the support of a clavicle, if such a bone were present. The coracoid is very small, and is perforated by a large foramen. The two peculiar bones now generally regarded as belonging to the sternum were not coössified.

The humerus is comparatively short. The radius and ulna are much elongated, the latter being longer than the humerus, and the radius about the same length. The ulna has a prominent olecranon process, and is a stouter bone than the radius. The carpal bones were quite short, and appear to have been only imperfectly ossified. The fore foot, or manus, was very long, and contained three functional digits only. The first digit was rudimentary, the second and third were nearly equal in length, the fourth was shorter and less developed, and the fifth entirely wanting, as shown in Plate VII.

In the functional digits (Plates II. III. IV.), the phalanges are elongate, thus materially lengthening the fore foot. The terminal phalanges of these digits are broad and flat, showing that they were covered with hoofs, and not with claws. The limb as a whole was thus adapted to locomotion or support, and not at all for prehension, although this might have been expected from its small size and position.

The elongation of the fore-arm and manus is a peculiar feature, especially when taken in connection with the ungulate phalanges. It may, perhaps, be explained by supposing that the animal gradually assumed a more erect position until it became essentially a biped, while the fore limbs retained in a measure their primitive function, and did not become prehensile, as was the case in some allied forms.

The pelvis has already been described by the writer. Its most notable features are seen in the pubis and ischium, the former having a very large expanded prepubis with the postpubis rudimentary, while the shaft of the ischium is greatly elongated.

The femur is long, and the shaft nearly straight. The great trochanter is well developed, while the third trochanter is large and near the middle of the shaft. The external condyle of the distal end is projected well backward, indicating great freedom of motion at the knee.

The tibia is shorter than the femur, and has a prominent cnemial crest. The distal end is much flattened, and the astragalus is closely adapted to it. The fibula is very straight, with its lower end flattened and closely applied to the front of the tibia. The calcaneum is large, with its concave upper surface closely fitted to the end of the fibula. Of the second row of tarsals, only a single one appears to be ossified, and that is very small and thin, and placed between the calcaneum and the fourth metatarsal, nearly or quite out of sight.

The hind foot, or pes, had but three digits, the second, third, and fourth, all well developed and massive. The terminal phalanges were covered with broad hoofs. The first and fifth digits were entirely wanting.

The reptile here restored was nearly thirty feet in length when alive, and about fifteen in height in the position represented in Plate VII. The remains were obtained in the Laramie of Wyoming. Among the associated fossils were the gigantic *Triceratops* and *Torosaurus*, herbivorous dinosaurs, and with them the diminutive Cretaceous mammals recently described by the writer.

III.—On the Occurrence of Concretionary Masses of Flint and Chert in the Maltese Limestones.

By John H. Cooke, F.G.S., etc.

THE late Admiral Spratt, R.N.,[1] and Dr. John Murray,[2] of the "Challenger" Expedition, have, in their brochures on Maltese Geology, made allusion *en passant* to the occurrence of chert nodules in the *Globigerina* limestones of the Maltese islands. Neither of these gentlemen, however, gave any details of the nature, mode of occurrence, or distribution of the concretions, an omission which was probably due to the restricted area of the horizon at which the nodules are found, and to the irregular and sparse manner in which they are distributed.

The following notes on these points, which were collected in the course of my geological investigations into the fauna of the formation, may not, therefore, be without some value to present and future students of Maltese geology.

The *Globigerina* limestones in which the concretions occur occupy the second place in the ascending order of the Maltese formations. They attain a maximum thickness of about 250 feet, and comprise a series of layers or beds which vary in number in different localities from four to ten. Between the beds themselves the variations are but slight, and are of a chemical rather than of a lithological or a palæontological character, consisting generally of a greater or lesser percentage of carbonate of lime according to the extent to which the beds were influenced by the river-waters which brought down detrital products from the surrounding continental areas.

---

[1] "This deposit often contains nodules of a flinty texture, viz., chert, in which are fish-scales." The Geology of Malta and Gozo. Malta, 1854, p. 7.

[2] "Nodules of flint and chert are found in some of the layers." "The Maltese Islands, with special reference to their geological structure." Scot. Geog. Mag., September, 1890, p. 24.

The following table shows the relative positions, and the more prominent characteristics of the sub-divisions.

Formation.	Sub-divisions.	Thickness.
Globigerina Limestone.	*a.* A greyish, fine-grained freestone.	15 to 20 feet.
	b. First seam of phosphatic nodules.	1 foot.
	c. A whitish, compact, fine-grained freestone.	40 to 50 feet.
	d. Second seam of phosphatic nodules.	1 to 2 feet.
	e. A soft blue limestone with phosphatic nodules irregularly distributed throughout it.	50 feet.
	f. A white, highly calcareous limestone with flint and chert nodules.	30 to 50 feet.
	g. A coarse-grained yellowish freestone.	20 to 40 feet.
	h. Fourth seam of phosphatic nodules.	2 to 4 feet.

It would be irrelevant to here consider these beds in detail; I shall, therefore, simply regard the formation as being broadly divisible into three sections, *i.e.*

a. Deposits containing from 30 per cent. to 80 per cent. of carbonate of lime; the residue being principally made up of alumina with a small quantity of silica. Dr. John Murray considers this portion of the bed to have been formed on a descending sea-floor in about 300 fathoms of water, and to have been within the influence of river-waters and their detrital products.

b. Deposits containing from 80 to 90 per cent. of carbonate of lime. Probably deposited in about 1000 fathoms of water.

c. Deposits containing 70 per cent. and less of carbonate of lime; and consisting for the most part of the remains of comparatively shallow-water organisms. These were laid down on a rising sea-floor, and in about 300 fathoms.

The *Globigerina* limestones may, therefore, be considered as being a series of deposits laid down during a gradual but constant change in the position of the sea-bottom, the deposits in division *b.* having been formed about the time when the maximum depression was being attained, and at a considerable distance from any shore-line.

In the lower parts of this intermediate division considerable quantities of siliceous concretions are found to occur in certain localities, of which the cliffs at Fommer Rih, the escarpments around the slopes of Uied Mars-el-Forn, Uied Sakkaja, and Uied Hempsia, and the quarries of Tad-dual, Tal Gauchi, and Inghieret furnish some of the most characteristic specimens. In none of the more impure varieties of limestone in either the upper or the lower divisions have any specimens been found.

The concretions assume a variety of forms occurring sometimes as irregularly shaped masses of two or more feet in length, and from six to twelve inches in thickness, or as spheroidally shaped nodules having more or less symmetrically shaped outlines. In composition they also vary greatly, the larger masses being composed of flint (silex), while the smaller nodular forms consist of chert (phtanite), which is an impure calcareous variety of flint.

At Fommer Rih and along the hill-slopes already referred to, the differential degradation to which the nodular masses and their matrices have been subjected has resulted in the complete isolation of the former, and they have thus been caused to project from the faces of the cliffs and escarpments as bold conical bosses.

In none of the nodules are these exposed portions entire, as all of them have been more or less acted upon by the same meteoric agencies that have removed the limestone from around them.

In many instances the disintegration has proceeded by the peeling off of laminated scales, while in others small shapeless masses have broken away and left the weathered surfaces irregularly prismatic in character.

Viewed with the naked eye both the nodules and the larger masses are exceedingly homogeneous; but when examined under a low magnifying power, sections of foraminifera, small molluscs, and other organisms are to be seen embedded.

In none of the specimens that I have examined have I observed any of the fish-scales to which Spratt alluded in his brochure; but I cannot venture to say that, therefore, such remains are either absent or of rare occurrence.

In colour both the flint and the chert vary widely, graduating through all the intermediate shades of grey, fawn, blue, and black.

The interiors of the nodules are generally of a jet black colour, a fact which is probably due to the presence of carbonaceous matter, as much of it disappeared when subjected to the action of the blow-pipe flame. This black interior often graduates into a semi-translucent grey towards the outer edges, thus causing the concretions when cut transversely to present the appearance of being made up of a series of concentric layers of varying hues; such specimens are not, however, so common as are the uniformly black, grey, and fawn coloured varieties.

The limestone surrounding the masses and the nodules is invariably changed into chert more or less pure in character. This cherty limestone is often of a colour similar to that of the enclosed nodule, and unless carefully examined it is often difficult to say where the line of demarcation between the two lies.

The former, however, is neither so compact nor does it present, when broken by means of a smart blow with a hammer, the conchoidal fracture which is so characteristic of the latter.

From the similarity which exists between the characters of these flints and cherts and those which occur so plentifully in other limestone formations, it seems probable that the origins of both are to be traced to analogous causes.

The Maltese varieties are found only in the most highly calcareous portions of the strata, embedded among the *Globigerinæ* of which the greater part of the formation is made up.

It was probably to the action of these and other organisms in eliminating the silica held in solution in the sea-water, and afterwards to chemical action, whereby further precipitation of silica on and around that which had been previously secreted by the organisms, that these nodular masses had their origin.

IV.—ANALYSIS OF THE FULLERS EARTH OF VRONGOCH.

By P. GERALD SANFORD, F.I.C., F.C.S.

SOME four years ago I published in this MAGAZINE[1] an analysis of the Fullers Earth of Nutfield, Surrey. The Nutfield samples were given to me by A. Sheridan, Esq., C.E. I now wish to record the analysis of a large bed of this clay at Rhiwlas, Vrongoch, near Bala, N. Wales. The beds are about 60 feet thick, and are upon the property of R. J. Lloyd Price, Esq. In this case also, the samples were sent to me by Mr. Sheridan. The two samples A and B are of somewhat different composition. B contains considerably more silicate of alumina and less alumina than A. A would of course, from a fuller's point of view, be the better earth of the two. Although the Nutfield and Vrongoch earths are so similar in composition, their appearance is very different: the Surrey earth has a greasy feel, a hard smooth surface, that can only just be scratched with the finger nail; the Vrongoch earth is soft and friable, dark grey in colour, and very earthy, and dissolves in water to the extent of about 4 per cent. of its weight. As regards the grease absorbing properties, the Vrongoch earth appears to be even better than the Nutfield samples. Fullers Earth appears to be an excellent material for cleaning chemical apparatus that is greasy, or soiled with fats and oils.

ANALYSIS No. 1.—SAMPLE A.

Matter insoluble in acid	=	78·27	per cent. consisting of	Silica = 63·25 p.c.
Alumina (Al_2O_3)	=	12·95	,,	Fe_2O_3 = 8·72 ,,
Peroxide of iron (Fe_2O_3)	=	0·42	,,	Al_2O_3 = 6·30 ,,
Lime (CaO)	=	0·82	,,	
Manganese oxide	=	trace		78·27
Magnesia (MgO)	=	1·65	,,	
Sulphuric acid (SO_3)	=	0·31	,,	
Alkalies (K_2O, Na_2O)	=	2·02	,,	
Combined water	=	3·56	,,	
		100·00		

ANALYSIS No. 2.—SAMPLE B.

Matter insoluble in acid	=	78·53	p. c. consisting of	Silica = 57·01 p.c.
Alumina	=	2·84	,,	Fe_2O_3 = trace
Peroxide of iron ...	=	8·50	,,	Al_2O_3 = 21·52 p.c.
Lime	=	0·90	,,	
Manganese oxide ...	=	trace		78·53
Magnesia	=	2·30	,,	
Sulphuric acid ...	=	0·05	,,	
Alkalies	=	2·12	,,	
Combined water ...	=	4·76	,,	
		100·00		

[1] GEOL. MAG. Decade III. Vol. VI. No. 304, p. 455.

V.—The True Horizon of the Mammoth.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.S.A., F.G.S.

I AM highly gratified that some of the difficult problems connected with the Mammoth and its surroundings, which have been too long ignored, are at last attracting something like adequate attention; and I regret that Mr. Jukes-Browne should withdraw from the controversy without, as it seems to me, doing justice to the cause he represents. In his concluding letter he adds nothing but a reference to Mr. Clement Reid and Mr. Horace B. Woodward, neither of whom need a vicarious spokesman. I wish he had been able to point to one well attested example to prove his case. I must again press upon him the fact that mere rhetoric is of no avail in this or any other scientific discussion. What we need is to be pointed to some example within our four seas of the occurrence of a land-surface dating from the Mammoth period underlaid by true drift.

I will now turn to Mr. Stirrup, who, while indulging in some amusing dogmatism, does favour us with some arguments. These arguments I will endeavour to meet. First in regard to Switzerland. Here I confess I cannot quite follow him. He does not traverse the statements of the chain of witnesses whom I quoted who have examined the beds at Dürnten and Utznach, including Sir Charles Lyell and Heer himself, and who came to the conclusion that the Mammalian beds there are under and not over the drift; but he apparently thinks he answers the virtually unanimous stratigraphical testimony by asking me if I think the Mammoth, the *Elephas antiquus*, the *Urus*, and the Red Stag lived together in Switzerland before the Glacial period. I certainly think they lived there before the distribution of the drift; just as they did in England at the time when the brick-earths of the Thames Valley were being deposited. This I have argued at considerable length in my big book on the Mammoth. All the authorities known to me place these Zurich beds on the same horizon as the Forest-bed of Norfolk. Is there anybody anywhere who puts the Forest-bed of Norfolk above and not under the Drift? I think Mr. Stirrup should explain himself rather more definitely.

Let us now turn to another part of Mr. Stirrup's communication to which he devotes a considerable space, but the relevancy of which I am at a loss to understand: I mean what he has to say in reference to the well known journey of Baron Toll and Herr Bunge to the Bear Islands. Mr. Stirrup does not seem to be aware that although the detailed scientific work of the expedition is only in course of publication, an interesting work giving an account of their journey has been published for some time and is naturally familiar to those who take an interest in the history of the Mammoth.

What possible support Mr. Stirrup can find for his contention in the work of the two Russian explorers I quite fail to see. The fact of beds of ice underlying the Tundra deposits of North-Eastern Russia and of Siberia has been known for a century. That the

Mammoth carcases are not found in this ice but in frozen gravel and mud has also been known for a long time, and the whole question is discussed at some length in a part of my Mammoth book, which Mr. Stirrup might, I think, have profitably consulted.

That the ice in question is palæocrystic ice dating from Pleistocene times is no doubt a new suggestion, at least, as far as I know, but what evidence there is of this I altogether fail to see. Those who have hitherto written on the subject have explained these ice-beds very rationally. The ground in Northern Siberia is permanently frozen at a depth of a few feet from the surface. The stratum thus frozen prevents a complete drainage of the surface water, which, percolating through the ground, reaches the frozen layer cannot get away and presently becomes itself frozen. Thus a thin bed of ice is formed which gradually grows in thickness between the permanently frozen subsoil and that part of it which is thawed every year. This is the natural consequence of the present climate of Siberia. When the Mammoth and its companions lived there and lived, as I think I have elsewhere proved, as far north as the Bear Islands, the climate must have been very different. Not only was the country covered with forests but the land-shells which have been found with the remains of these forests with Mammoth bones, are incompatible with the existence during the Mammoth age of permanently frozen soil in Siberia. This I have urged at some length in the book already quoted. It is for Mr. Stirrup, who has apparently applied himself to these problems for the first time quite recently, to face this dilemma; I think he ought to have faced it before he used flippant phrases about such a master of observation and logic as Cuvier. I am bound to say I cannot see that he has in the slightest degree qualified the conclusion of the great French philosopher and naturalist, a conclusion endorsed in more recent times by two such authorities as D'Archiac and De Lapparent.

Turning to the researches of M. Tchernyschew, I am equally at a loss to know what conclusion Mr. Stirrup would base them upon. That the Tundras of North-Eastern Europe and of Siberia are underlaid by gravels, is a very elementary fact; they have been described by several explorers and notably by Middendorff and Schmidt. These gravels consist of water-rolled local pebbles, some of which are doubtless scratched as they are in all gravels, but so far as the evidence before me, and it is very considerable, goes, there is not a trace in them of *erratics*, of boulders with flat sides and of the other real footmarks of glacial action; nay, more, the experienced geologists like Nordenskiold, Von Cotta, and others, who have carefully examined this very problem on the ground, are agreed that no traces of an Ice Age, except the one in progress now exist in Siberia, neither in the mountains nor in the plains. Here, again Mr. Stirrup has surely, like the Spanish Knight, been tilting at a windmill.

Again, he bids me remember that in America the Mammoth and the Mastodon occur in the superficial deposits. Of course they do, but what has this to do with the question. There are many places within easy reach of Manchester where mountain limestone shells occur at the surface. Does this prove that the mountain limestone is more recent than the so-called glacial beds? The fact is we can follow the Mammoth beds from Europe right across Asia, and when we cross Behring's Straits we find them again under precisely the same conditions in Alaska, and we can follow them in detached fragments right down to Ohio and further, and whether we find the bones in the North of Russia, in Siberia, in Alaska, or in the Salt Swamps of Ohio, their contemporaneity seems established. What we want evidence of is, not the distance at which a Mastodon skeleton has been found from the surface, that is immaterial, but whether it lies upon *true* drift or not.

I do not dispute that occasional molars of Mammoth, etc., occur in the Drift. Every casual student has found many kinds of early fossils in that formation, which are merely boulders. What we need is not the production of samples of these bone-boulders or of detached logs of wood, but as Dr. Hicks says, evidence of an actual land-surface with Mammoth remains in it, planted over and not under the Drift.

That Man and the Mammoth have occurred together in caverns is a perfectly elementary fact. They have similarly occurred in the loess; but what has this to do with the question. That palæolithic man was pre-Glacial in the sense in which the word is generally used, that is to say, that he lived before the widespread distribution of the Drift? I have no doubt about myself. May I ask Mr. Stirrup, however, to explain what he means by saying that the Lehm *is uniformly spread over the ancient or glacial alluviums* and that it *certainly belongs to the closing phases of the Ice-Age.* I should like to see some evidence of this besides a mere *obiter dictum.* To my mind if there is a deposit anywhere which is a flood deposit and not a glacial deposit it is that curious calcareous loam which in China, in the United States, and in Central Europe is called Loess or Lehm; which in South America is called Pampas mud; and which in Russia is called Chernozem. That it contains scattered bones and shells of land mollusks is true enough. It is no less true, as it seems to me, that it was deposited after and not before the Mammoth age, and that the Mammoth and the human bones and the land-shells in it were derived from the pre-existing land-surface.

I have now examined every argument and every fact adduced by Mr. Stirrup except his references to Falsan and Favre. These you will allow me to criticize on another occasion. Apart from them it would seem that the case for the foreign existence of a post-Glacial Mammoth, as presented by Mr. Stirrup, fails as completely as the English case, presented by Mr. Jukes-Browne, does.

On such a critical matter as the true horizon of the Mammoth on which so much strong and dogmatic language has been used by those who champion its post-Glacial survival, it is surely not unreasonable to ask for the production of a single case which will bear examination and criticism to support the contention. Geology is, or ought to be, an inductive science and not a survival of mediæval scholasticism.

VI.—RESTORATION OF *MASTODON AMERICANUS*, CUVIER.

By Professor O. C. MARSH. M.A., Ph.D., LL.D., F.G.S., Etc.

(PLATE VIII.)

THE great abundance and good preservation of the remains of the American *Mastodon* have led to various restorations of the skeleton. The best known of these is that made by Prof. Richard Owen, in 1846, based upon a skeleton from Missouri, now in the British Museum.[1] Another restoration was made a few years later by Dr. J. C. Warren, based mainly on a very perfect skeleton from Orange county, New York.[2] This skeleton is now preserved in the Warren Museum in Boston. A third restoration was made by Prof. James Hall, from a skeleton found at Cohoes, New York, and now in the State Museum of Natural History, in Albany.[3] These restorations are all of importance, and taken together have made clear to anatomists nearly all the essential features of the skeleton of this well-known species.

Additional discoveries have since brought to light more perfect specimens, one of which, now in the Yale Museum, is perhaps in the best preservation of any skeleton of the American *Mastodon* yet discovered, and this has been used by the writer in the restoration, one thirty-second natural size, given on Plate VIII.

The position chosen in this restoration is one which seems especially fitted to bring out the massive proportions of the animal, and, at the same time, to show nearly all the characteristic features of the entire skeleton. The animal, as thus represented was, when alive, about twelve feet in height, and perhaps twenty-four feet in length including the tusks.

This animal was fully adult, as the last molars above and below are in place and somewhat worn. The epiphyses of the vertebræ, moreover, are nearly all coössified with the centra, and in some of them, the sutures are obliterated. The epiphyses are also firmly united to the limb bones.

The tusks were very large, and considerably divergent. There were no inferior tusks, and no traces of their alveoli remain. The penultimate and last molars are present above and below in fine preservation, the former considerably worn.

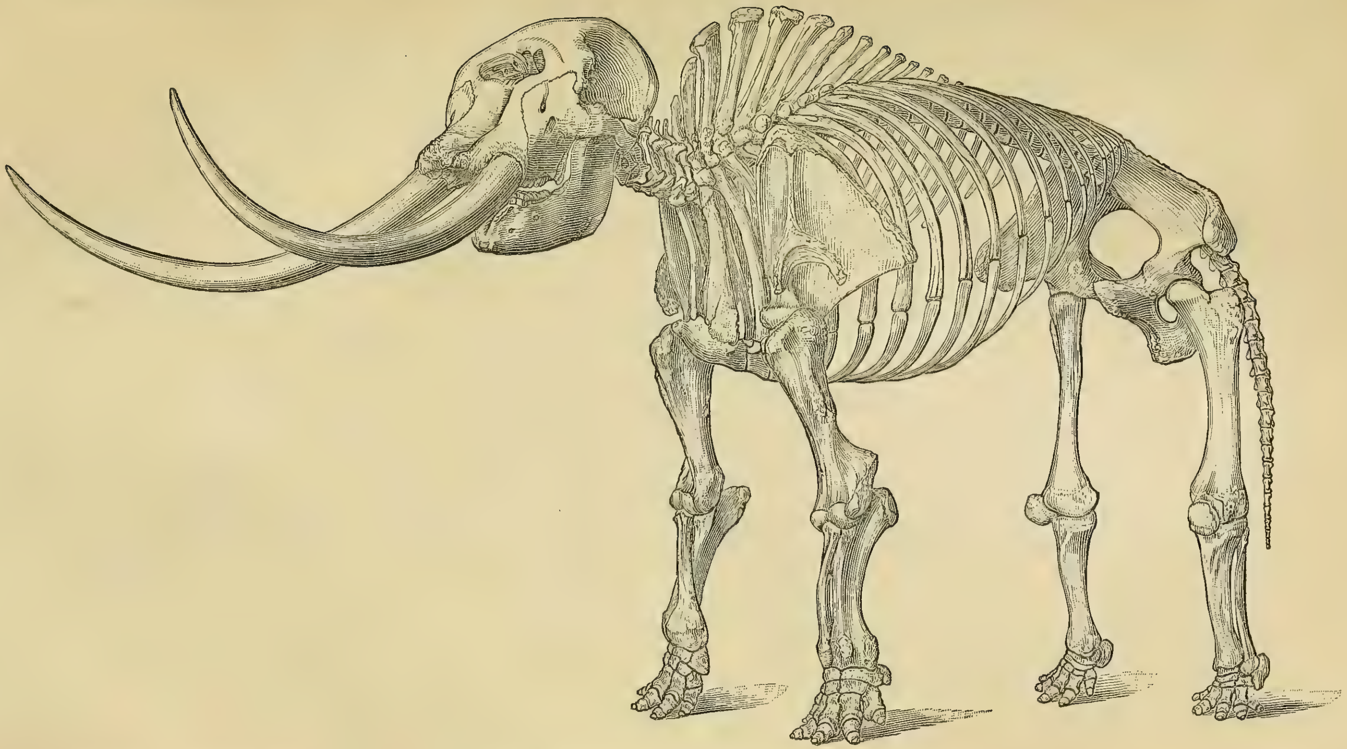
Other features of this skeleton, and especially the various new anatomical points it discloses, will be discussed by the writer elsewhere.

---

[1] British fossil Mammals and Birds, fig. 102, p. 298, London, 1846.

[2] Description of a skeleton of the *Mastodon giganteus* of North America, pl. xxvii. Boston, 1852.

[3] Report of the New York State Cabinet of Natural History for the year 1867, plate vi. Albany, 1871.



Mastodon Americanus, Cuvier. $\frac{1}{32}$ nat size.

NOTICES OF MEMOIRS.

I.—How the Waters of the Ocean became Salt.[1] By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

THERE are many things in the world around us to which we are so accustomed from childhood that we never stop to enquire why they should be so. That rivers and lakes should consist of fresh water, and that the sea should be formed of salt water, seems so natural that we consider them as not only matters of course, but essential to the physical economy of the world; and if perchance our attention is called to the fact that some inland lakes are formed of salt water we proceed to investigate the cause of so unusual an occurrence—one which being exceptional requires special explanation. But how few of the thousands and millions who traverse the ocean or dwell upon its shores put to themselves the question "Why are its waters salt?" And this, notwithstanding that it is daily receiving supplies of fresh water both from the rain which falls upon its surface and from the rivers which empty themselves into it. Clearly there is something here which *does* require special investigation, a question which *does* need solution, because, as far as the supplies afforded by the rain and rivers are concerned, the ocean waters ought apparently to be fresh rather than salt.

2. In using the terms "fresh" and "salt" here, and in the following pages, I do so in the popular sense of the words. Scarcely any natural water, except rain, is absolutely free from dissolved salts. All rivers contain them to a greater or less extent, as do also the waters derived from wells and springs. Such waters, however, are called (and properly called) "fresh," which does not necessarily mean water absolutely devoid of salts in solution; but when the proportion of salts is so great as to cause the water in which they are dissolved to appear "salt" to the taste, then the term salt water or brine is applied to them. The varieties of saline waters and the degrees of salinity are innumerable, and their properties and uses vary accordingly. There are the salt waters of the Dead Sea—so acrid as to be nauseous to the taste; there are those of the ocean, not so acrid: there are the varieties of mineral waters, and the brine springs highly impregnated with sodium chloride. But it is not necessary to go further into this branch of the subject; all that is necessary is to understand clearly the meaning of the terms we employ, and in the following essay I shall use the words fresh, brackish, and salt, as applied to water in the sense they are popularly understood.

3. But before entering upon the discussion regarding the cause or origin of the saltness of the oceanic waters we may endeavour to ascertain whether this highly saline character has characterised these waters throughout a very long period of geological time. Now the evidence we can safely rely upon in this part of our enquiry is mainly derived from the character and affinities of the organic forms

---

[1] Paper read at a meeting of the Victoria Institute, January 16, 1893.

of past geological ages. At the present day the molluscan and other forms which inhabit the ocean waters are distinguishable from those which inhabit fresh water lakes and rivers, while there are numerous others, such as the *Actinozoa* or corals, star-fishes, crinoids, sea-urchins, or echinoderms, exclusively confined to oceanic waters at the present day. The Brachiopods and the Cephalopods are specially characteristic of oceanic waters of the present day, and are therefore of special value in the attempt to determine the character of the waters which they inhabited in past geological times.

4. Now representatives of all these forms are found not only in Tertiary and Secondary, but even in early Primary or Palæozoic strata. Not only in the Cretaceous and the Jurassic strata, but also in the Carboniferous, Devonian, Silurian, Ordovician and Cambrian formations do we find corals, crinoids, starfishes, sea-urchins, various forms of Brachiopods and Cephalopods, differing indeed specifically from, but sometimes generically related to, those of the present day. The forms which are thus preserved to us in a fossil state are only those which were furnished with a stony or horny skeleton or integument. Many other forms there were which had no calcareous skeleton, and consequently have not been preserved in a fossil state, but which are represented in the ocean waters of the present day; and if these be allowed for, it becomes clear that amongst the invertebrate forms of marine life, those of the present day were largely represented in very early geological periods.

5. Such being the case we are justified in coming to the conclusion that the waters of the ocean must have been salt from very early geological times; but it by no means follows that they were fully as saline as those of the present day.

The forms of life which require the high salinity of existing ocean waters were possibly represented by others capable of sustaining life when the salinity was only half as great as it is now. We know that some forms, such as those of the oyster, cockle, etc., are capable of surviving in the Baltic, or of ascending estuaries, where the water is almost brackish. Degrees of temperature, purity (or freedom from sediment), and other conditions were probably of greater importance in determining the existence of life than degrees of salinity. Adaptability to the conditions of environment has doubtless been a law of nature amongst marine forms as well as those of the air and the land throughout all past time.

6. It is scarcely necessary to state here that the occurrence of beds of rock salt in several formations, especially in the Trias of the British Isles and of Europe, affords no evidence as regards the degree of salinity of the sea water in geological times. At no period have the waters of the ocean been so saturated with saline matter as to admit of the deposition of beds of rock salt. It has sometimes been suggested that such deposits may have been formed by the accidental accumulation of sand bars, owing to which portions of the ocean have been cut off from the main mass and the salts have been deposited as the waters have decreased

and become supersaturated by evaporation. But the mode of occurrence of the known beds of rock salt lend little support to this view; and recent investigations have led to the conclusion that deposits of rock salt have been accumulated over the floors of inland salt lakes like that of the Dead Sea in Palestine, along whose banks such deposits occur in the form of terraces which once formed the bed of the inland lake itself, when at a higher level than at present, but owing to the lowering of its waters are now exposed along its western margin, as in the case of the terraced hill known as Jebel Usdûm. Another fatal objection to the view of the marine origin of salt-rock is to be found in the fact that this rock generally consists of nearly pure chloride of sodium, while ocean water contains large proportions of the chlorides of calcium, magnesium, and potassium, the precipitation of which would result in a deposit very different from that of the rock-salt of Cheshire and Worcestershire, which is composed of 98·30 per cent. of chloride of sodium and only small traces of other salts.

7. But in addition to the evidence derived from organic forms of the primæval ocean we apparently possess very remarkable direct evidence that the waters were highly saline. It is known that some strata of the Upper Silurian period in North America are saliferous, constituting the Onondaga salt group and the Trenton and Chazy limestone series.[1] These strata are characterised by large numbers of marine organisms, and there can be no doubt that they were formed in the waters of the Silurian seas. They also yield large quantities of saline waters which are used in commerce, and in which chloride of sodium predominates; and as the strata are often in the condition of basins below the level of the outer ocean, Dr. Sterry Hunt has inferred that the waters with which they are saturated were originally those of the Palæozoic ocean in which the strata were deposited. In other cases, however, where the strata are upraised above the ocean level and highly inclined, the same author considers that surface waters have gradually replaced those originally contained in the strata.[2] Thus we are justified in inferring, not only from organic, but from direct physical evidence, that the waters of the early Silurian oceans were salt.

8. On examining samples of water taken from the open ocean of various regions and far from land, it has been found that the proportion of salts and carbonates do not vary much. This is doubtless owing to that wonderful system of currents by which the waters are kept in a state of perpetual movement, and owing to which there is a constant interchange of the warmer waters of the equatorial region with the colder of the polar. Sea water is essentially a chlorinated

---

[1] Dana states that in the State of New York the salt is made from strong brine by sinking wells varying from 150 to 340 feet in depth. It takes from 35 to 45 gallons of this water to make a bushel of salt, whereas it takes 350 gallons of sea water for the same result.

[2] "Chemical and Geological Essays," p. 104.

alkaline mineral water, the saline contents of which consist chiefly of sodic, magnesic, potassic, and calcic chlorides and sulphates, together with a number of other substances in much smaller proportion. The total amount of dissolved contents in the water of the open ocean varies from about 28 to 39 grammes per litre. Forchhammer fixes the mean amount of such contents at 34·404 grammes per litre,[1] and the mean proportions of the constituent substances to each other and 100 parts of chlorine are as follows[2]:—

Sodium.	Magnesium.	Calcium.	Chlorine.	Total saline constituents.
14·26	6·642	2·114	100	181·10

9. What is most striking in this analysis is the large proportion of chlorine, and the greatest difficulty we are met with in order to account for the salts of sea water is the abundance of this gas. Recollecting that chloride of sodium is the most abundant salt both in most salt lakes and in sea water, we are justified in seeking for a solution to our problem by an examination into the mode of origin of salt lakes.

10. Now there is one peculiarity which characterizes all salt lakes over the surface of the globe, namely—that they have no outlet; they are closed lakes. Whether we take the case of the salt lakes of Western America, those of Central Asia and the Dead Sea, we shall find that they are not drained by rivers.

11. In such cases the lakes are constantly receiving supplies of water from streams and springs, but do not give it off in the same manner, inasmuch as it is evaporated into the air as fast as it falls. In the case of freshwater lakes it is otherwise. Here the water of the streams which enter the lake is at least partially discharged by means of rivers flowing out, in consequence of which the water remains fresh, as the saline ingredients are carried away as fast as they are delivered. Of these two varieties of inland lakes we have remarkable examples in the case of the Dead Sea and the Sea of Galilee. In the former case the river Jordan entering at the northern end keeps up a constant supply, but this lake, which is about 1292 feet below the level of the Mediterranean, has no outlet, in consequence of which the water supplied by the Jordan passes away into the atmosphere in the state of vapour. In the case of the Sea of Galilee it is otherwise. The river which enters at the north passes out again at the south; hence the water of the lake is fresh and supports an abundant fauna of fishes and molluscs, while the waters of the Dead Sea are (as the name indicates) absolutely destitute of living beings, and fish entering it from the Jordan immediately perish. If there had been an outlet to the southwards from the Dead Sea into the Gulf of Akabah, and a continuous stream had been flowing from the time the depression was formed, the waters of the Dead Sea would have only differed from those of the Sea of Galilee by a somewhat greater proportion of salts and carbonates. Several other examples might be cited, but those of the Sea of Galilee and the Dead Sea are the most familiar and striking.

---

[1] Phil. Trans. civ. 303, *et seq.*

[2] Watt's Dict. Chem., vol. v. 1019.

12. There are two ways by which we may account for the salinity of the ocean waters from very early periods of geological time. First, by supposing that the primæval waters were saturated with acid gases which were held in suspension in the vapour surrounding the incandescent globe; or secondly, that the salinity resulted from a process resembling that by which salt lakes of the present day have been formed.[1]

13. We must, I think, concur with Dr. Hunt that from some cause or other, chlorine largely abounded in the waters of the primæval ocean, as by far the greater proportion of the salts are chlorides, and chlorine is but very slightly represented in river waters at the present day.

14. In contrast to the above, which may be called "the chemical theory," we may now consider that which may be called "the geological theory," though it very much depends upon certain chemical processes.

15. If we compare the analyses of waters brought down by rivers into the ocean at various parts of the globe we shall find that the matters in solution are very much the same as those which we find dissolved in oceanic waters; the proportions are doubtless immensely different, but the ingredients are essentially similar. Now, what are the dissolved ingredients of river waters? They are calcium, magnesium, sodium, potassium, a little iron, silica, alumina, and other matters, in combination with carbon-dioxide (carbonic acid gas), sulphuric acid, hydrochloric acid. Of these the carbonates of lime and magnesia are the most abundant, but chlorides of sodium and magnesium are almost always present even in waters where there can be no suspicion that they have been introduced by any artificial means. These constituents are also found in even larger proportions in the waters of natural springs; and in

---

[1] Of the former method Dr. Sterry Hunt may be considered the chief exponent, and in order that I may not unintentionally misrepresent his views I will give them here in nearly his own words. Referring to that period in the physical history of our globe in which it may be presumed to have been in a molten state surrounded by an atmosphere and an envelope of vapour of water, he says:—"There would be the conversion of all the carbonates, chlorides and sulphates into silicates, and the separation of the carbon, chlorine and sulphur in the form of acid gases which, with nitrogen, vapour of water, and a probable excess of oxygen could form the dense primæval atmosphere. The resulting fused mass would contain all the bases as silicates, and must have resembled (when consolidated?) certain furnace slags or volcanic glasses. The atmosphere charged with acid gases which surrounded this primitive rock must have been of great density. Under the pressure of a high barometric column condensation could take place at a temperature much above the present boiling point of water, and the depressed portions of the half-cooled crust would be flooded with a highly heated solution of hydrochloric and sulphuric acids, whose action in decomposing the silicates can easily be understood. The formation of the chlorides and sulphates of the various bases and the separation of silica would go on until the affinities of the acids were satisfied, and there would be a separation of silica taking the form of quartz, and the production of sea-water holding in solution, besides the chlorides and the sulphates of sodium, calcium, and magnesium, salts of aluminium and other metallic bases. The atmosphere being thus deprived of its volatile chlorine and sulphur compounds, would gradually approximate to that of our own time, but would differ in the greater amount of carbonic acid gas." "Chemical and Geological Essays," p. 40 (1875).

such chlorine occurs, sometimes in considerable quantity, in combination with sodium, magnesium, and potassium. Spring water coming as it does directly from the strata, or from rocks of various kinds, is generally free from any external or artificial ingredients, hence it may be regarded as the chief source of supply of the carbonates and salts found in streams and rivers. If we enquire what is the origin of spring water, the reply is simple. It is water which originally falling on the surface as rain or snow has percolated downwards into the rocky crust, and taking up the soluble matters with which it comes in contact, bursts forth at the surface along lines of fault, fissure, or other natural ducts. The relative proportions of the ingredients of sea water and of rivers or lakes may be gathered from the selected examples on p. 171.

16. From the above results of the analysis of various waters, it will be seen that there is no essential difference between the waters of the ocean and those of lakes and rivers except in the proportions of the dissolved ingredients. There are, of course, occasionally substances specially abundant, as is the case with bromine in the waters of the Dead Sea, probably derived from the volcanic district on its borders; on the other hand, silica ($Si\ O^2$), which is not mentioned in the waters of the Atlantic Ocean in the analysis of Von Bibra, is certainly present in those waters, and supplies the material from which sponges, diatoms, and radiolaria build up their skeletons. It will be observed also that chlorine and sulphuric acid is present in all the waters, and these gases uniting with the alkalies, give rise to the salts which are so abundant in the waters of the ocean and of closed lakes.

17. In considering the manner in which springs and surface waters have become impregnated with salts and carbonates, we have to recollect that all rocks decompose in presence of the atmosphere. This is mainly due to the carbonic acid (carbon-dioxide) contained in the air and rain water, which acts upon felspathic rocks, composed, as we have seen, of double silicates of alumina, potash, and soda. Ebelman has well explained the process by which basaltic and similar rocks are decomposed under the influence of the atmosphere. The carbonic acid (carbon-dioxide) combines with the lime and magnesia, while the silica is liberated in a soluble form. The felspar is more stable than the pyroxene and hornblende, but it ultimately gives way, forming a hydrous silicate of alumina. Thus we can account for the presence of carbonates of lime and magnesia, free silica, and by a further process in presence of sulphuric acid and chlorine of the various sulphates and chlorides.

18. Now, as bearing on the fact of sodium chloride (or common salt) being the chief ingredient in oceanic waters, as well as in those of the Dead Sea and most salt lakes, we must recollect that the soda-felspars are much more soluble than the potash-felspars, and on this account we have probably a true cause of the predominance of sodium chloride. The rocks composed in the main of such felspars as labradorite, albite, oligoclase, and andesine, were therefore more powerfully acted upon than those composed of orthoclase

PROPORTION OF SOLUBLE INGREDIENTS IN THE WATERS OF THE OCEAN AND SPECIAL LAKES AND RIVERS.
Parts in 1,000,000.

	Total Solid Contents.	Ca.	Mg.	Na.	K.	CO_2.	SO_4.	Cl.	Br.	SiO_2.	Fe.	Authority.
Atlantic Ocean (41° 18′ N., 36° 28′ W	38,400	556	1,198	11,719	668	...	3,029	20,839	387	...	...	Von Bibra.
Caspian Sea (2 versts S.W. of Pischnoi) ...	6,296	191	409	1,444	139	77	1,337	2,737	...	...	40	Göbel.
Dead Sea...	240,483	9,000	19,883	47,918	6,385	...	497	154,442	2,176	...	11	Herapath.
Rhine at Basle	169	55	4·8	0·6	...	86	15·4	1·5	...	2·1	...	Pagenstechor.
Aar, near Berne	216	66	10·0	0·3	...	103·3	33·7	0·3	...	2·7	...	,,
Severn, Wales...	38.7	3·0	2·0	6·1	1·2	2·0	12·8	8·2	...	2·0	...	Franklin and Odling.
Thames at Twickenham...	321	83·8	4·7	9·2	4·2	119·9	31·4	14·2	...	3·9	...	Clark.
Thirlmere	51·5	4·3	1·2	4·9	...	10·9	7·5	11·0	...	0·7	...	Way.
Bala Lake	27·9	1·5	0·8	3·9	0·9	1·9	3·5	7·3	...	0·3	...	Frankland.

Decimals are omitted in the case of sea waters.

and sanidine; but even in these cases many orthoclase granites contain proportionate quantities of the soda felspars such as oligoclase and albite, and the decomposition of these components would hasten that of the less soluble varieties.

19. It seems not improbable from certain considerations connected with the organic structures of the ancient world, that carbon-dioxide was more abundant in the atmosphere of Palæozoic times than at present. The enormous quantity of carbon which must have been extracted from the air during the Carboniferous period in order to the formation of the beds of coal at intervals all over the world, seems to favour this view; and if this be so, then we may suppose that previous to the Carboniferous period, the air was highly charged with carbon-dioxide, and the process of decomposition on the land surface was carried on with even greater rapidity than at the present day; but even had this not been the case, it only requires a sufficiently long period in order to bring about the chemical reactions necessary to the salinification of the oceanic waters.

20. We are now approaching the conclusion of our enquiry. From the examples of closed lakes we can determine the process of salinification with the utmost certainty. Throughout greater or shorter periods, these lakes have been receiving the waters of rivers bringing down, both mechanically suspended sediments and chemically dissolved salts, silicates, and carbonates. The sediments are precipitated over the bottom of the lakes, and the water being carried off into the atmosphere in the form of vapour as fast as it enters, leaves behind the dissolved ingredients. These necessarily augment in quantity, and ultimately the waters of the lakes become saturated with salts and carbonates, which are then deposited.

21. Now the ocean is a closed lake of enormous magnitude. Throughout all geological time it has been receiving continual supplies from rivers, bringing down not only sediment, but salts and carbonates, together with free silica, in solution. The sediment is deposited over the ocean floor, and generally not far from the lands, while the dissolved ingredients are carried by the currents into all parts. Meanwhile the ocean surface is constantly giving off, particularly over the equatorial regions, enormous quantities of vapour, which are carried into the higher regions of the atmosphere, and are precipitated in the form of rain and snow over the lands. Part of course falls on the sea again, but the greater quantity falls on the land surfaces, and is returned to the ocean in streams charged with a fresh supply of the salts and carbonates it had left behind in the ocean.[1] The consequence of this process must clearly be that the saline ingredients have been increasing in the oceanic waters from the earliest periods down to the present day. As regards the carbonates of lime and magnesia, and the silica which are being carried into the ocean by the rivers, we have no difficulty in accounting for their uses. Of these materials, the shells and skeletons of the molluscs, echinoderms, reef-building

---

[1] This process of evaporation and supply by rivers is accurately described in the Book of Ecclesiastes i, 7.

corals, foraminifera, sponges, radiolarians, and diatoms and other forms are built up, and as these structures are continually being formed, and the materials solidified as fast as they enter the oceans, there is no reason why they should augment. Hence the proportion of carbonates of lime and magnesia in the ocean waters may be very much the same now as it was in Silurian and Carboniferous times.

22. We are thus brought to the conclusion that the saltness of the sea may have originated in very much the same way as has that of the Dead Sea, Lake Oroomiah, or the Great Salt Lake of Utah, or many others which might be named, and which possess in common the characteristic of having no outlet. When the great envelope of vapour which surrounded the incandescent globe began to condense upon its cooling surface, the resulting waters, though containing, as Dr. Sterry Hunt supposes, acid gases, were destitute of saline ingredients. The process of salinification began with the first streams which entered the seas from the bordering uplands, and this process carried on throughout the long ages preceding the Silurian period brought the waters to a condition suited to sustain the life of forms of inhabitants representative of those which inhabit the ocean at the present day. These long ages may be supposed to include, not only the Archæan and Azoic periods, but that during which the first crust was in course of formation over the incandescent globe.

II.—On some new Reptiles from the Elgin Sandstone. By E. T. Newton, F.G.S. From the Proceedings of the Royal Society, Vol. 52.

During the last few years a number of Reptilian remains have been obtained from the Elgin Sandstone at Cuttie's Hillock, near Elgin, which are now in the possession of the Elgin Museum and of the Geological Survey. These specimens represent at least eight distinct skeletons, seven of which undoubtedly belong to the Dicynodontia, and one is a singular horned Reptile new to science. All the remains yet found in this quarry are in the condition of hollow moulds, the bones themselves having entirely disappeared. In order, therefore, to render the specimens available for study, it was necessary, in the first place, so to display and preserve these cavities that casts might be taken which would reproduce the form of the original bones. Gutta-percha was found to be the most suitable material for taking these impressions; and in some instances, especially in the case of skulls, the casts had to be made in several parts and afterwards joined together.

The first specimen described is named *Gordonia Traquairi*; it is the one noticed by Dr. Traquair in 1885, and referred to the Dicynodontia; besides the skull, it includes fragmentary portions of other parts of the skeleton, and is contained in a block of sandstone which has been split open so as to divide the skull almost vertically and longitudinally. The two halves have been so developed that casts made from them exhibit the left side and upper surface, as well as the main parts of the palate and lower jaw. In general appearance this skull resembles those of *Dicynodon* and *Oudenodon.* The nasal openings are double and directed laterally; the orbits are large and look somewhat forwards and upwards. The supra-temporal fossa is large, and bounded above by the prominent parieto-squamosal crest, and below by the wide supra-temporal bar, which extends downwards posteriorly to form the long pedicle for the articulation of the lower jaw. There is no lower temporal bar. The maxilla is directed downwards and forwards to end in a small tusk. Seen from above, the skull is narrow in the inter-orbital and nasal regions, but wide posteriorly across the temporal bars, although the brain-case itself is very narrow. There is a large pineal fossa in the middle of a spindle-shaped area, which area is formed by a pair of parietals posteriorly and a single intercalary bone anteriorly.

The palate is continuous with the base of the skull; the pterygoids on each side send off a distinct process to the quadrate region. Towards the front the median part of the united pterygoids arches upwards, and the outer sides descend, forming a deep groove; from the evidence of other specimens it is clear that the palatines, extending inwards, converted this groove into a tube, and thus formed the posterior nares. The ramus of the lower jaw is deep, with a large lateral vacuity, and the two rami are completely united at the symphysis. The back of this skull is not seen, but two other specimens, referable to this same genus, show that the occiput had two post-temporal fossæ on each side.

This specimen is distinguished from *Dicynodon* by the presence of two post-temporal fossæ on each side of the occiput, by the small size of the maxillary tusk; and probably by the elongated spindle-shaped area enclosing the pineal fossa, and also by the slight ossification of the vertebral centra.

A second and much smaller specimen, provisionally referred to *G. Traquairi*, has, besides the skull, a fore-limb well preserved. The humerus of this shows the usual Anomodont expansion of its extremities; its large deltoid crest is angular, and set obliquely to the distal end.

Three other species are referred to the same genus, namely:—

Gordonia Huxleyana, which is distinguished from *G. Traquairi* by its proportionately wider and more depressed skull, and by the absence of the concavity between the orbits which is present in the latter species. The humerus has the distal extremity oblique to the deltoid crest, which was probably rounded and not angular.

G. Duffiana has the skull even wider than in *G. Huxleyana*, and the portion of a humerus found with this skeleton has the two extremities set nearly at right angles to each other.

G. Juddiana has an elongated skull resembling that of *G. Traquairi*, but the parietal crests are less developed, the bones of the nasal region are much thickened and overlap the nasal apertures, the small tusk is placed a little further back and points more directly downwards, and the pineal fossa is smaller than in either of the other species.

A second generic form is named *Geikia Elginensis.* This is a skull nearly allied to *Ptychognathus*, Owen, but is distinguished by its shorter muzzle and the entire absence of teeth; the upper part of the skull, between the orbits, is also peculiar, forming a deep valley open anteriorly, with a ridge on each side, the anterior end of which forms a large prominence above and in front of the orbit. The occiput has only one (the lower) post-temporal fossa open on each side. The maxilla is produced into a tooth-like prominence, which occupies a similar position to the tusks of *Gordonia*; but the bone is too thin to have supported a tooth, and in all probability it was covered by a horny beak. The lower jaw has a strong symphysis, a distinct lateral vacuity, and the oral margin, at the front of each ramus, bears a rugose prominence.

Elginia mirabilis is the name proposed for the skull of a Reptile, which, on account of the extreme development of horns and spines, reminds one of the living Lizards *Moloch* and *Phrynosoma.* The exterior of this skull is covered in by bony plates, the only apertures being the pair of nostrils, the orbits, and the pineal fossa. The surfaces of the bones are deeply pitted, as in Crocodiles and Labyrinthodonts. The horns and spines, which vary from $\frac{1}{4}$ in. to nearly 3 in. in length, are found upon nearly every bone of the exterior. The development of the epiotics and the arrangement of the external bones resemble more the Labyrinthodont than the Reptilian type of structure, while the palate, on the other hand, conforms more nearly to the Lacertilian type, and, with the exception that the pterygoids are united in front of the pterygoid vacuity, agrees with the palate of *Iguana* and *Sphenodon.* There are four longitudinal ridges along the palate, some of which seem to have carried teeth. The oral margin was armed with a pleurodont dentition, there being on each side about twelve teeth with spatulate crowns, laterally compressed and serrated. With the exception of the smaller number of the teeth, we have here, on a large scale, a repetition of the dentition of *Iguana.* This peculiar skull seems to show affinities with both Labyrinthodonts and Lacertilians, and is unlike any living or fossil form; its nearest, though distant, ally apparently being the *Pareiasaurus* from the Karoo Beds of South Africa.

REVIEWS.

I.—Fauna der Gaskohle und der Kalksteine der Perm-formation Böhmens. Band III. Heft 2. By Prof. Anton Fritsch, of the Bohemian University of Prague. Prague, 1893.

ALL who are interested in the study of the Palæozoic Vertebrata will welcome the appearance of a new part of Prof. Anton Fritsch's great work on the Permian Fauna of Bohemia, dealing, as this part mainly does, with a problematic group of extinct fishes, whose affinities have troubled palæichthyologists since the time of Agassiz. It is that of the Acanthodei, the consideration and illustration of which occupy twenty-six of the thirty-two pages, and seven of the twelve plates contained in the present "Heft," while in the remainder a commencement is made with the description of these "Teleostomi," which we have been accustomed to call "Ganoidei."

Only one family of Acanthodei is represented in the newer palæozoic rocks, that of the Acanthodidae, having only one dorsal spine, and of this family the genera and species occurring in the Permian of Bohemia are first treated descriptively, a separate chapter being reserved for general considerations. Three genera come under consideration, namely *Traquairia, Protacanthodes* and *Acanthodes,* of which the two former are new.

Traquairia pygmaea is the name given by Dr. Fritsch to a small Acanthodian fish whose salient peculiarities are—the total absence of ventral fins and the tooth-like acumination of the posterior angles of the scales,—the dorsal spine is, as in Acanthodes, behind the anal. Numerous examples of the one species of the genus have occurred at Nyřan, and a few also at Třemošna.

In *Protacanthodes* the scales have also a spine or tooth-like projection which, however, passes off from their hinder *margin*; the ventrals are described as very small, while behind them a long narrow *median* dermal fold passes to nearly as far as the anal spine, which as in *Traquairia* and *Acanthodes* is placed in front of the dorsal. It is much to be regretted that only one single example of the one species, *P. pinnatus*, Fr., has occurred. Dr. Fritsch seems himself a little doubtful about the minute ventrals, and I cannot altogether rid myself of the notion, that what he interprets as a median fold may possibly be *one of a pair* of ventral fins, fringe-like as they are in *Acanthodes* proper. Of the last mentioned genus three species are noticed, of which *A. punctatus* is founded upon spines occurring at Kounova, while *A. Bronni*, Ag., and *A. gracilis* (Beyrich) are retained as distinct species.

As regards the general structure and morphology of the group, Prof. Fritsch exercises a wise caution in not committing himself to such wonderfully detailed results as those announced by Reis in a paper published three years ago.[1] He places the Acanthodei among the Elasmobranchii as is now done by most authors, and among the evidences of this affinity he adduces the tooth-like projection on the posterior aspect of the scale, in *Traquairia* and *Protacanthodes*, which he compares with those of *Centrina*. The resemblance in shape is interesting, but I cannot follow the author when he says: "Es zeigt sich dass die älteren Formen der Acanthodiden diese bezahnten Schuppen trugen und ihre jüngeren Vetreter Acanthodes diesen Zahn verloren und blos den viereckigen Theil ohne jeden Vorsprung behalten haben." I certainly cannot regard either *Traquairia* or *Protacanthodes* as specially archaic in structure, and I certainly know of no Devonian or Carboniferous Acanthodian which is possessed of similar "bezahnte Schuppen."

As regards the skeleton he finds that the cartilage calcifications are as in the Xenacanthidæ formed by polygonal plates. No teeth were discovered in any of the Bohemian genera,—the edentulous character of *Acanthodes* being thus conclusively confirmed.

---

[1] Geognostische Jahreshefte der königl. baier. Oberbergamtes 1890.

In the shoulder-girdle he designates the well-known ossicle supporting the pectoral spine as "clavicula" and therefore does not adopt Mr. Smith Woodward's view that this element in *Acanthodes* is a basal piece or Basipterygium, while interpreting as clavicle the very same piece as it occurs in *Diplacanthus*. Here, however, Prof. Fritsch expresses himself very cautiously, saying that comparative anatomists would find a difficulty in agreeing about these points even "wenn sie die Sachen frisch vos sich hatten."

The morphology of the paired limbs of *Acanthodes* is certainly a very difficult question, and Dr. Fritsch ventures to suggest a new theory, namely that the entire pectoral spine is in fact a calcified archypterygium. To that view I cannot say I am converted, any more than to the very different one entertained by Mr. Smith Woodward.

Before leaving the Acanthodei, Prof. Fritsch inserts a couple of pages concerning *Machæracanthus Bohemicus* (Barrande), which he, along with Reis, considers referable to this group, owing to the fact that in one of the specimens described and figured by Barrande, a bone resembling an Acanthodian clavicle occurs in close association with fragments of two of those spines, while on the under side of the stone, square shaped scales like those of *Acanthodes* are found. For this he proposes the new generic and specific names *Dinacanthodes Süssii*. Now it is evident that if the specimen with the clavicular fragment discovered by Prof. Süss belongs to the same species as the others also described and figured by Barrande on a preceding page of his work as *Ctenacanthus Bohemicus*, and Prof. Fritsch nowhere says that it does not, the latter specific name has undoubted priority and cannot be displaced.

We must agree with the author in desiring a fresh investigation into the nature of the other species of *Machæracanthus*, on the results of which indeed depends the validity of the name *Dinacanthodes*. For if the Bohemian spine should really prove to belong to the same genus with Newberry's *Machæracanthus sulcatus*, the type of the genus, then Prof. Fritsch's new name cannot be maintained.

After a brief notice of a scale of *Megalichthys* (*M. nitens*, Fr.) from Kounová, the author enters the domain of the Acipenseroid fishes, for which he, however, retains the older, though less appropriate name of Chondrostei, the description of the remarkable genus and species *Trissolepis Kounoviensis* bringing the present part to a conclusion. This he makes into the type of a new family, Trissolepidae, of which I shall translate his definition.

"Body Palæoniscus-like, scales behind the head denticulated, on the body cycloid, on the tail rhombic. Anterior margins of fins without fulcra. Palate with strong teeth. Gill arches with strong gill-rakers. Middle line of the back only in front of the dorsal fin with V scales, which gradually pass into the fin rays."

Now as these characters appear to me to be only of generic and not of family importance, I cannot see in them any sufficient reason for separating *Trissolepis* from the Palæoniscidae, as they now stand, and when that enormous family comes to be subdivided, I should be inclined to place the genus in question not far from *Amblypterus* on account of the direction of the suspensorium and the form of the opercular apparatus.

Anyway, *Trissolepis Kounoviensis* is a most interesting fish, the consideration of which leads us to imagine—what would the older writers who pinned their palæichthyological faith to Agassiz's system, have said to a "Lepidoid" with round scales on its body and angular ones on its tail! But this is now not the only instance of such an apparent anomaly.

The restored drawing of *Trissolepis* is indeed very nice, but it seems to me that he has put the orbit in an impossible position for a fish of its affinities. If Dr. Fritsch should prove correct in this detail, then it will have to be frankly conceded that the Trissolepidæ do form a family quite sufficiently separated from the Palæoniscidæ.

A curious feature of the genus is the presence of large, prominent, tooth-like gill-rakers attached to the branchial arches on their anterior aspect. *Apropos* of this, Prof. Fritsch observes in a footnote that, "die starke Bezahnung der Kiemenbögen lässt die Frage enstehen ob *Harpacanthus fimbriatus*, Traquair, nicht ein ähnlich bezahnter Kiemenbogen ist." Now I can only answer that all Teleostomous ossified branchial arches, which I have ever examined, had a groove posteriorly for the branchial vessels and nerves, which is *not* found in *Harpacanthus*; secondly, that I never saw in any of them a central pulp cavity or canal, which *is* present in the spine to which I gave the above-mentioned generic name. The question need not, I think, arise again.

Such criticisms, notwithstanding Prof. Fritsch's new part is a very valuable contribution to palæichthyological science, and one on the production of which its author is certainly to be congratulated.

R. H. Traquair.

II.—A. E. Brehm, Merveilles de la Nature: La Terre, les mers et les continents, Geographie Physique, Géologie et Minéralogie; par Ferdinand Priem. Paris, 1893. Royal 8vo. pp. 708, with 757 Illustrations. (J. B. Baillière et Fils.)

SO many important works on Physical Geography have appeared during the last twenty-five years that one is led to marvel whence the source of supply of this perennial stream of literature can have been derived.

We owe the initiation of this form of knowledge to the greatest naturalist and traveller of his time, Alexander von Humboldt, best known to English students by his latest work, "Kosmos" (1848), in which he contemplates all created things as linked together and forming a perfect whole, animated by internal forces. Charles Darwin's Journal of a Naturalist, in a voyage round the world, is another work which doubtless contributed to lay the foundations of the many subsequent Physiographical studies which have since seen the light in this country.

The most important French work, *bearing the samè title,* "*La Terre,*" as the present work, was written and published by J. Elisée Reclus, the well-known French geographical writer and traveller, in Paris, about 1864, and an English edition in four volumes appeared in 1871, which was followed by a second edition some years later. Professor Edouard Suess in Vienna has also contributed "Das Antlitz der Erde" (the face of the Earth) and his lamented son-in-law, Prof. M. Neumayr, has published "Erdgeschichte der Erde" (the History of the Earth); while in England, the writings of Lyell, Ansted, Page, Lapworth, Huxley, Geikie, Young, Douglas, and many others have reduced the study of the Earth to a definite science, but at the same time have surrounded it by a charm peculiarly its own.

The Editor of this new Edition of Brehm's celebrated work we are told has carefully brought his subject up to date in all matters relating to most recent scientific researches. In the first part we have an outline of the history of geology, then we consider the terrestrial globe in its relation to the other heavenly bodies, and afterwards study the various elements of our planet: its atmosphere, its lands and seas.

A great part of the work is occupied with a description of those continual changes of the terrestrial surface, due to the action of the seas, to running waters, and to the subterranean forces; especially the questions relative to glaciers, volcanoes, and earthquakes, are fully treated with all the development which they admit.

The minerals and rocks are next passed in review, and special attention is directed to economic materials; the metals, and the precious stones. The volume terminates with an outline of the faunas and floras which people the earth. The book is profusely illustrated with 757 engravings, many of them of most excellent merit; but in some instances it is difficult to understand the reason for their introduction. Thus in the sections relating to the faunas of the globe, one would have expected to see the most characteristic forms figured, rather than those which are more rare. The "Lemming" is not more characteristic of circumpolar lands than the white bear, the walrus, the musk sheep, the reindeer, or the elk.

The "tree-porcupine," is not so characteristic of North America as the Bison, now, alas, nearly exterminated by man, or the Prairie-Dog (*Spermophilus*). The *Orycteropus* of the Cape rather represents its distant South American relatives, the Great Ant-eater, the Tree-sloth, and the Armadillos; and with the Pangolin (*Manis*) points to a former migration of the South American Edentata into South Africa, possibly *viâ* the old Antarctic Continent. But the Zebras, Quaggas, Elands, and other Antelopes; the Giraffes, Hippopotami, and Elephants, with Lions, Hyænas, and Ostriches, better represent the Cape-fauna than the Aard-Vark or the Manticora Beetle. The "Aye-aye" (*Cheiromys*) is not so characteristic of Madagascar as the ordinary Lemurs, being an extremely rare form in that Island.

The "Bower-bird" (*Chlamydera maculata*) is the only illustration of the fauna of Australia; the *Thylacinus* and *Ornithorhynchus* for Tasmania; and the *Apteryx* for New Zealand.

Under "the Calcareous rocks and their principal varieties" we have an account and illustrations of "Travertin," with plant-impressions; of washings of the Chalk, showing the various forms of *Foraminifera*, of which it is so largely built up; of Crinoidal limestone and figures of the various forms of *Encrinus* and *Pentacrinus*, of whose broken remains they are composed. Of Corals and Coral-reefs with figures of the zoophytes and their skeletons and of the Islands and Barrier-reefs built up by their combined labours. Of the various kinds of Radiolarians and Foraminifera, both recent and fossil, and the rock-formations their microscopic organisms have so largely assisted to form: all this is excellently told. There are numerous figures of fossil organisms, ranging from the *Paradoxides* of the Cambrian to the Bernissart *Iguanondon* and from the *Archæopteryx* of Solenhofen to the Mammoth of Siberia and the *Cervus giganteus* of the Irish peat-deposits. On p. 10, Fig. 23, of *Lepidodenron aculeatum*, the block has accidentally got turned upside-down, the leaf scars being reversed. The woodcuts of geological scenery are most excellent. The Book (like so many others printed in France and Germany) is issued *without binding* in a paper wrapper, the effect of which is that the edges become speedily "dogs-eared." It is to be regretted that so fine a work should not be issued in an equally handsome cover, and well bound. We wish the new edition of Brehm all the success which has attended his other and earlier publications.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—ANNUAL GENERAL MEETING.—February 17th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.

The Secretaries read the reports of the Council and of the Library and Museum Committee for the year 1892. In the former the Council once more congratulated the Fellows on the continued financial prosperity of the Society.

The number of Fellows elected during the year was 40; of these 33 qualified before the end of 1892, together with 18 previously elected Fellows, there being thus a total accession of 51 Fellows during the twelvemonth. As, however, from this number a deduction of 59 must be made for losses by death, resignation, and removal, and for new Fellows compounding, there is an actual decrease in the number of Contributing Fellows of 8. The total number of Fellows, Foreign Members, and Foreign Correspondents at the close of 1892 was 1400.

The Balance-sheet for the year 1892 showed receipts to the amount of £2927 14*s.* 9*d.* and an expenditure of £2358 11*s.* 3*d.* Moreover, the sum of £528 3*s.* 0*d.* was expended in the Purchase of Stock, and the balance in favour of the Society at December 31st, 1892, amounted to £327 19*s.* 10*d.*

The Report of the Council further referred to the successful claim and recovery from the Commissioners of H. M. Inland Revenue of four years' taxes under Schedules A and C, and in conclusion announced the awards of the various Medals and proceeds of Donation Funds in the gift of the Society.

The Report of the Library and Museum Committee enumerated the additions made during the past year to the Society's Library, announced the completion of 22 previously imperfect sets of serials, and the continuation of the work of registering the type-specimens in the Museum by Mr. C. Davies Sherborn.

In presenting the Wollaston Medal to Professor Nevil Story Maskelyne, M.A., F.R.S., F.G.S., the PRESIDENT addressed him in the following words:—Professor Maskelyne,—

The Council of the Geological Society have this year awarded to you the Wollaston Medal, in recognition of your researches in those branches of science which the Founder himself cultivated with so much success. We do not forget that Wollaston invented the reflecting goniometer, and that no one has been more skilful in the use of that instrument than yourself. Thirty years ago you were enabled, in this way, to make an exact determination of the form of the minute crystals of Connellite; and the later discovery of larger crystals of that mineral has only served to confirm the accuracy of your original determination. During the thirty-five years that you have occupied the Chair of Mineralogy at Oxford you have ever insisted on symmetry as being the essential feature of the crystalline systems. Contemporaneously with your professional duties you devoted twenty-three years of your life to the development of the mineral collections at the British Museum. These collections had for some years previously been without a mineralogist in charge. With the co-operation of the late Mr. Thomas Davies, your apt pupil and assistant, the collection was rearranged; and when you left the Museum to enter Parliament, in 1880, the classification of the entire collection had reached a high pitch of perfection, while the collection itself had been in many respects enriched.

The investigation of extra-telluric bodies has long since attracted your attention, though the want of a chemical laboratory must have been felt by one who had already proved, from his numerous chemical papers, the interest he took in that science. Failing this, you sought to recognize the individual minerals by the aid of the microscope, working on thin sections—a method now universally adopted in the study of terrestrial rocks. In this way, thirty years ago, you were enabled to determine many of the most important ingredients of meteorites, by means of the relation of the axes of optic elasticity to known crystallographic lines. The microscope was further applied to the mechanical separation of the different mineral ingredients of a meteorite, and the existence of such minerals as enstatite and bronzite demonstrated. Your research on the mineral constituents of the Busti meteorite will long remain an example to future workers. Further, in conjunction with the late Dr. Flight, you described the minerals of the diamantiferous rock of South Africa, suggesting that an enstatite rock, at points of contact with carbonaceous shales, was probably the original home of the diamond—an explanation which is now generally accepted.

Although for several years past your energies have found employment in another direction, we may venture to hope that your interest in those branches of science which Wollaston was desirous of promoting is in no wise lessened; and we trust that you may yet achieve results such as shall even further justify the Council in the selection they have made.

Professor Maskelyne, in reply, said:—Mr. President,—

In receiving at your hands the Wollaston Medal, I beg to thank the Council for the great honour they confer on me, and you, Sir, for the generous review in which you have sketched my past scientific life. When my first surprise at the Award gave way to other thoughts, the first of them was one of gratification at the Council having this year determined to give the Medal for studies so nearly connected with Wollaston's work, and to furthering which he rendered such distinguished services. To these you have alluded; and, in the kindly view you have taken of my work, I thank you for associating with it the names of some of those to whom I was much indebted in its achievement.

You have alluded, Sir, to the period—nearly a quarter of a century—that I was working at the British Museum as head of the Mineral Department. I am proud of the work done in those years, and it was done, as most good work is done, by few hands—mostly by those of Mr. Thomas Davies and myself. Davies came to me a young man fresh from the sea, and absolutely innocent of any scientific knowledge. He died a few weeks ago, in many ways an accomplished man—the best judge of a mineral in this country, and an admirable petrologist—a worthy son of William Davies, and a worthy recipient of the Wollaston Fund, which was awarded him some years ago. And, Sir, I have to thank you for naming another of the helpers in my work—Dr. Walter Flight. He, too, is no more; and there died in him one of the finest of laboratory manipulators and a very accomplished chemist.

But one name I must supply, of a man who more than thirty years ago came to London for a visit and remained to work in the Museum for some time. I allude to Viktor von Lang, the partner of Joseph Grailich in the splendid work done by the Vienna school of crystallography and physics, and who had already then a European name. That period of my life, in the continual companionship of so finely trained a physicist and crystallographer, was like a second education.

Then, Sir, you have alluded to the little school, if I may call it so, of Crystallography connected with my Chair at Oxford, and to the results of my teaching. The deduction of the laws of morphological and physical symmetry in crystals from the fundamental law of rational indices lay as a germ, though entirely undeveloped, in the Treatise and tracts of my late friend and master in the study of the science, Professor Miller of Cambridge. Modern crystallography has grown from that germ, and if I have helped in promulgating it in England through my lectures, I owe more to the students who attended those lectures than they owe to me in guiding them; for they have always kept high the standard of crystallographic work in their investigations as in their teaching. Among these I must mention my old friend, W. J. Lewis, now Professor at Cambridge; and I need only allude to the remarkable memoirs on "Thermic Dilatation in Crystals" and on the "Optical Indicatrix" by the able mathematician who succeeded me at the British Museum, Mr. Fletcher, and to the fine work of his first assistant, Mr. Miers, to justify me in saying that if I have had any merit in directing such men upon their way, it is to their own qualities that the success of that little Oxford school is due. Happily, if it were possible, would I divide that Medal among those who have so contributed to the winning of it, and retain as my own share the grateful remembrance that you, Sir, and the Council have thought me worthy to receive it, with the features stamped on it of that distinguished Englishman its Founder, the man to whom we owe the instrument—so simple, so accurate, and so indispensable—the reflection-goniometer; the instrument which made it possible for crystallography to become an exact science.

Finally, in respect to the last part of your observations, I may say that of the many duties imposed on me by my country during the past few years, I am relieved now of one of the weightiest, and shall be able, I trust, to devote much of the leisure of what may be left to me of life to the subjects which were heretofore my chief interest; and in cordially thanking you, Mr. President, and the Council for this, the greatest honour you can confer, I may assure you that it will be a great incentive to me still to strive to be worthy of it.

The President then handed the Murchison Medal to the Rev. Osmond Fisher, M.A., F.G.S., and addressed him as follows:—Mr. Fisher,—

The Council have this year awarded to you the Murchison Medal, together with a sum of Twenty Guineas, in consideration of the work you have done in the general advancement of geological science. They recognize the importance of your work at once as a stratigraphical geologist and as a physicist who has devoted his attention to problems in connection with the Earth's crust. It is now nearly forty years since your paper on the Purbeck strata of Dorsetshire made its appearance, worked out while you had charge of a parish in Dorchester, your connection with this part of the world arising from the fact that your father was formerly Vicar of Osmington. During the last 30 or 35 years a very great number of works have eminated from your pen, and have been published either separately or in the Proceedings of our own or of some other Society.

These works attest the wide range of the subjects in which you have taken an interest and the extent of your scientific research. The subjects may be classified under four principal heads:—1. Earth sculpture and its results; 2. The discrimination of the various superficial deposits collectively spoken of as Drifts; 3. Description of the stratigraphy and palæontology of the later Jurassics of Dorsetshire and the Older Tertiaries of the Isle of Wight; 4. Investigations into the conditions of the Earth's crust and speculations as to the causes of the great operations which take place therein, either observed in action or inferred from their results.

Whether dealing with denudation in Norfolk, with the Bracklesham Beds on the coasts of the Channel, or making use of mathematical analysis to determine what must be the resultant form and status of the Earth on the hypothesis of a certain not improbable combination of forces, brought to bear upon certain possible conditions of the crust, you have given evidence of that philosophic spirit which has ever been your characteristic. And we have also seen how suggestive your work has been from the large series of similar investigations which have often followed the publication of your results.

The Rev. O. Fisher, in reply, said:—Mr. President,—

I regard the award of this Medal to me as to some extent a token that my efforts to find a *modus vivendi* between geologists and physicists have been appreciated by the Geological Society. I regret to say that the leading physicists, at least in this country, make no sign at present either of accepting or of rejecting my conclusions; but the important questions at issue seem on the point of receiving recognition from American mathematicians.

It is with peculiar pleasure that I shall treasure the Murchison Medal. I had the honour many years ago of a slight acquaintance with the distinguished Founder of this endowment, and I recollect still, how, at the reading of the first paper which I offered to this Society, Sir Roderick expressed approbation of my views, which were somewhat opposed to the strictly uniformitarian theories then chiefly in vogue. Words of encouragement falling from so great a man could not fail to be valuable to an amateur at his first venture before a learned Society; and that the same Society should after many years endorse in so appropriate a manner the favourable opinion which he expressed of my early effort affords me the greatest satisfaction.

In presenting the Lyell Medal to Mr. E. Tulley Newton, F.G.S., the President addressed him as follows:—Mr. Newton,—

The Council have awarded to you the Lyell Medal, with a sum of Twenty-five Pounds, in recognition of the valuable services you have rendered to British Palæontology. In addition to your well-known memoirs, "On the Chimæroid Fishes of the Cretaceous rocks," and "On the Vertebrata of the Forest-bed Series," published by the Geological Survey, you continue to contribute important papers to the Royal, Geological, and Zoological Societies, to the Geological Magazine, and to the Geologists' Association. Nor must we forget the very valuable synopsis of the Animal Kingdom brought out by you in 1887.

Your knowledge of the fossil Mollusca has been made available by way of joint contribution to more than one paper, while you have further increased our knowledge of the Vertebrata of the British Isles in almost every class. The fishes have always constituted one of your favourite subjects, and lately you have brought to notice a new species of *Clupea* from the Oligocene of the Isle of Wight, and a form of *Semionotus* from the Keuper of Warwick, besides contributing to the history of Eocene Siluroids. Your recent papers in the "Proceedings" of the Royal Society prove that you have not neglected the Reptilia, while your "Further Contributions to the History of the Norfolk Forest-bed" and your notice of some new Mammals from the Crags show that the Mammalia have not been forgotten. Even in the class Aves you have indicated the presence of the Red-throated Diver in Pleistocene Beds at Mundesley and more recently described *Gastornis Klaasseni* from the Lower Eocene of Croydon.

In presenting you with this token of their appreciation of your work, the Council feel sure that you are by no means likely to relax those efforts in descriptive palæontology which have already borne such excellent fruit.

Mr. NEWTON, in reply, said:—Mr. President,—

I am deeply sensible of the honour which the Geological Society has conferred upon me to-day, by the Award of the Lyell Medal, and regret that the work, of which you, Sir, have spoken so kindly, bears so small a proportion to the reward bestowed upon it; for the Medal of Sir Charles Lyell is in my estimation one of the highest honours which a geologist can hope to receive.

It has been my good fortune to have been placed in a position which has brought me valuable specimens to work out, and if the results of my labour are in any way of scientific value, it is due to training, in years gone by, under my esteemed master in science, the Rt. Hon. Professor Huxley.

I receive this Award with the greater pleasure, because it is to me a further evidence of the kindly feeling existing between this Society and the members of the Geological Survey, who are to-day rejoicing and participating in the honours conferred upon two of their colleagues.

I desire to express my warmest thanks to the Council for their much valued Award, and to you, Sir, for the kind words with which it has been accompanied.

In handing the Bigsby Medal, awarded to Prof. W. J. Sollas, D.Sc., LL.D., M.A., F.R.S., F.G.S., to Mr. J. J. H. Teall, M.A., F.R.S., F.G.S., for transmission to the recipient, the PRESIDENT addressed him in the following words:—Mr. Teall,—

The Council have awarded to Prof. Sollas the Bigsby Medal in acknowledgment of his continued researches on the morphology and mineral constitution of the fossil Sponges. Fifteen years have elapsed since a President of this Society, in presenting him with the balance of the proceeds of the Wollaston Donation Fund, expressed a belief that he would continue to benefit palæontological science by his researches on these obscure forms of life. That those anticipations have been fully realized, the important character of Prof. Sollas's subsequent work in this direction most clearly proves.

But it is not in Palæontology alone that he has evinced his interest in Geological Science, as his paper on the Silurian district of Rhymney and other contributions to the geology of the neighbourhood of Bristol serve to demonstrate. Nor have his efforts relaxed since he became Professor of Geology and Mineralogy in the University of Dublin, as the "Transactions" of the Royal Dublin Society and the Royal Irish Academy can testify. We recognize the philosophical biologist in his memoir on the Origin of Freshwater Faunas, and the mineralogist and chemist in his contributions to a knowledge of the Granites of Leinster. It is satisfactory to reflect that one who has done so much and in so many ways for science is still sufficiently young to receive the Bigsby Medal, and should he happily be spared, it is not unreasonable to suppose that still higher honours may await his efforts.

Mr. TEALL, in reply, said:—Mr. President,—

I have been requested by my friend Prof. Sollas to express his thanks to the Council of the Geological Society for the honour which they have conferred upon him. Had he been present in person I feel sure that he would also have thanked you, Sir, for the kind words with which you have accompanied the Award. He desires me to read the following communication:—

"If the first impulse in the study of science arise from a longing for deeper insight into Nature, a second, at once powerful and innocent, is a desire for the approbation of elders. Thus I gratefully receive this Bigsby Medal awarded me by the Council, finding in it both reward, too little deserved, and stimulus to fresh endeavour.

"My old friend and whilom fellow-student, Mr. Teall, who, by the indulgence of the Society, represents me to-day, was its recipient in 1889, and he concluded his expression of thanks with an eloquent tribute to our revered teacher, Prof. Bonney. Here I can gladly follow where I fain would lead; for if any success has attended my studies, I owe it to the encouragement of our old tutor, who has never treated the designation 'in loco parentis' as a harmless College fiction, but has made of it through life a veritable truth."

The PRESIDENT then handed the Balance of the Proceeds of the Wollaston Fund, awarded to Mr. J. G. Goodchild, F.G.S., to Prof. T. McKenny Hughes, M.A., F.R.S., F.G.S., for transmission to the recipient, addressing him as follows:—Professor Hughes,—

The Council, in awarding the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Goodchild, have been desirous of expressing their sense of the value of his geological work in the North-west of England, and more especially of his description of the Glacial phenomena of the Eden Valley, as recorded in the Quarterly Journal of the Society. They also recognize his services in aid of science generally for many years past as Editor of the "Transactions" of the Cumberland and Westmoreland Association, and as the author of many interesting papers on Local Geology which have appeared in those "Transactions." The Council hope that his appointment in Edinburgh will not prevent him from still carrying on investigations in the field.

Professor HUGHES, in reply, said:—Mr. President,—

I have, as the oldest friend of Mr. Goodchild in this Society, been asked to receive and transmit to him the Proceeds of the Wollaston Fund. I feel more inclined to dilate upon my friend's deserts than upon the kindness of the Council in making the award to him.

I will try to compromise the matter by saying only that there is no man who will so keenly appreciate this recognition of his work, and no case in which the Society may reckon on a better return for this wholesome stimulus of encouragement.

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Mr. G. J. Williams, F.G.S., the PRESIDENT addressed him as follows:—Mr. Williams,—

The Balance of the Proceeds of the Murchison Geological Fund has been awarded to you by the Council in token of appreciation of your active researches amongst the Cambrian and Ordovician rocks of Ffestiniog and Harlech. You have done good petrological and palæontological work, both in the selection of rocks for thin sections, and in amassing a fine series of fossils. The exhibition of a portion of your collection at Chester, on the occasion of the International Congress Excursion in 1888, proved to be of great interest. The Council hope that this award may be fruitful in inducing you to persevere on the lines which you have already adopted with so much success.

Mr. WILLIAMS, in reply, said:—Mr. President,—

I beg to thank the Council of the Geological Society for the wholly unexpected honour they had conferred on me in awarding me the Balance of the Proceeds of the Murchison Geological Fund. I have been able to do but little work in the past, and I look upon this award as an aid to further research rather than a recognition of work already accomplished. If anything is needed as an incentive to further work, in addition to the pleasure derived from the work itself, I shall be able to look back on this Award as a "spur to prick the sides of my intent."

The PRESIDENT then handed one moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Miss Catherine A. Raisin, B.Sc., to Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S., for transmission to the recipient, addressing him as follows:—Professor Bonney,—

In asking you to forward to Miss Raisin one moiety of the Balance of the Proceeds of the Lyell Geological Fund, I am performing a very pleasing duty. Miss Raisin's excellent work, both in the field and with the microscope, so far commends itself to the Council that they have readily made this Award to a pupil of whom you may be justly proud. The considerable number of papers which that lady has contributed, both to the "Quarterly Journal," of the Geological Society and also to the GEOLOGICAL

MAGAZINE—all within the last six years—is a proof of her industry, while the papers themselves indicate an excellent knowledge of Petrology and a good eye for country. The Council, in making this Award, wish it to be regarded as an acknowledgment of past work, and at the same time as an encouragement for the future.

Professor BONNEY, in reply, said :—Mr. President,—

I have been requested by Miss Raisin to offer her thanks to the Council and Society in the following terms:—

"It is difficult for me to express the gratification which I feel at the honour that has been conferred upon me by the Council of the Geological Society. It gives me also peculiar pleasure to receive an award associated with the name of Sir Charles Lyell, whose 'Principles of Geology' was one of the earliest books to arouse my enthusiasm in that subject, and who by the terms of his Bequest gave evidence of an interest in the intellectual work of women, and even anticipated that they might in the future take part in scientific investigations. In addition to the personal honour, I welcome this recognition as an encouragement, not to myself only, but also to other women who are working at Geology and at different branches of Natural Science. I can assure the Society that their generous appreciation of the little which I have done will not be thrown away, but that I shall use my best endeavours in the future to carry on work worthy of their kind encouragement, worthy also of the instruction and guidance received at University College, the benefit of which I rejoice to have this opportunity of acknowledging."

Here I might sit down, but I cannot forbear from expressing my personal gratification at being chosen to represent so earnest and conscientious a worker. It brings me a further gratification. As life is in its afternoon we become conscious, often painfully, that we have failed in fulfilling our earlier ideals. My own work has been smaller in quantity and inferior in quality to what I had hoped, but, when one former pupil receives an Award and another a Medal, when the Secretaries designated for the coming year are two other old pupils, one feels that one has not wholly laboured in vain.

The PRESIDENT then presented the other half of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Alfred N. Leeds, addressing him as follows :—Mr. Leeds,—

The Council have awarded to you the second moiety of the Balance of the Proceeds of the Lyell Geological Fund, in appreciation of your long-continued and successful endeavours to collect and reconstruct the fossil Vertebrata of the Oxford Clay of the neighbourhood of Peterborough. In making this Award the Council bear in mind the readiness you have at all times shown to place the materials in your possession at the service of palæontologists desirous of availing themselves of your treasures. The Fund now awarded, besides being a recognition of past services, may serve to encourage you to work in the same direction.

Mr. LEEDS, in reply, said :—Mr. President,—

In returning thanks to yourself and the Council for this Award, I must say how astonished and pleased I was at so unexpected a recognition. It is more than twenty years since my brother (who now resides in New Zealand) and I began to collect fossils from the Oxford Clay. The late Prof. Phillips, of Oxford, was the first geologist to describe some of our specimens, which are also figured in his "Geology of Oxford." In 1874 Prof. Seeley described the remains of *Murænosaurus*, and since then he, Mr. J. W. Hulke, Mr. R. Lydekker, and Mr. A. Smith Woodward have written many papers for your Society upon other specimens of Saurians and Fishes which we had collected. From all these friends, and especially from Dr. H. Woodward, we have received the very greatest encouragement in our work.

You, Sir, have crowned our labours to-day, by your generous approval and the stamp of the "Lyell Award."

The PRESIDENT then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows and Foreign Members deceased since the last Annual Meeting, including Sir Richard Owen (elected in 1837), Mr. John Murray (elected in 1828), Col. T. W. Fletcher (elected in 1842), Mr. H. F. Blanford, Mr. T. Davies, Mr. H. J. Marten, Mr. Edw. H. Hargraves, Mr. Wm. Reed, Sir Jas. Brunlees, Mr. L. L. Dillwyn, Mr. A. Norman Tate, Mr. D. Corse Glen, Mr. Thos. Wynne, Major-General N. von Kokscharow (elected Foreign Member in 1879), and Professor J. S. Newberry (elected Foreign Member in 1883).

The other portion of the Address dealt with some recent work of the Geological Society, the subjects ranging over a period of six or seven years. These embraced Pleistocene Geology, Theories in connexion with Glaciation, Tertiary, Cretaceous, Jurassic, and Permo-Triassic Geology. The address further mentions that the number of papers on Pleistocene Geology has been very considerable, and many of them relate to the South-east and the South of England; those relating to Central England and South Wales were fewer in number, whilst the North had furnished but few papers. The great memoir on the Westleton Beds had provided much material for consideration, that portion relating to the Southern Drift being especially interesting. Reference was made to a paper on the Pleistocene succession in the Trent Basin, as forming a fitting introduction to the fascinating problems connected with the North Wales border on the one side, and with Flamborough Head on the other. From Scotland, notice was taken of some supplementary remarks on the Parallel Roads of Glen Roy. Speculations as to the evidence of a Palæozoic Ice-age, the date and duration of the Pleistocene Glacial Period, and a notice on misconceptions regarding the evidence of former Glacial Periods were also discussed.

The Tertiary Geology of the London and Hampshire Basins was considered, more especially in relation to the Upper Eocene, or Bartons, and their probable equivalents in West Surrey. Under this heading also comes the Geology of Barbados, since the Oceanic deposits in that island were held to be of late Tertiary age. These interesting discoveries were reviewed at some length, and the results compared with tables in the recently-issued 'Challenger' Reports. In Upper Cretaceous Geology the phosphatic deposits at Ciply and Taplow were noticed, and also the important correlations of the basement-beds in Norfolk, Lincolnshire, and East Yorkshire. The Lower Cretaceous beds at Speeton next passed under review, more especially in connexion with their somewhat difficult palæontology and possible equivalents in Eastern Europe. The address then went on to state that our knowledge of the Upper Jurassics of the East of England had of late years received considerable additions, that important correlations between our Upper Jurassic generally and their equivalents in the Jura had been effected, and that the Inferior Oolite and the Lias-boundary had received their share of attention, while a determined attempt had been made to refer a portion of the Red Rocks of South Devon to the Permian formation.

The Ballot for the Council and officers was taken, and the following were duly elected for the ensuing year:—*Council:* Prof. J. F. Blake, M.A.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; R. Etheridge, Esq., F.R.S.; Sir A. Geikie, D.Sc., LL.D., For.Sec.R.S.; Prof. A. H. Green, M.A., F.R.S.; Alfred Harker, Esq., M.A.; H. Hicks, M.D., F.R.S.; G. J. Hinde, Ph.D.; T. V. Holmes, Esq.; W. H. Hudleston, Esq., M.A., F.R.S., F.L.S.; J. W. Hulke, Esq., F.R.S.; Prof. J.

W. Judd, F.R.S.; R. Lydekker, Esq., B.A.; Lieut.-General C. A. McMahon; J. E. Marr, Esq., M.A., F.R.S.; H. W. Monckton, Esq., F.L.S.; Clement Reid, Esq., F.L.S.; F. Rutley, Esq.; J. J. H. Teall, Esq., M.A., F.R.S.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.; Henry Woodward, LL.D., F.R.S.; H. B. Woodward, Esq.

OFFICERS:—*President:* W. H. Hudleston, Esq., M.A., F.R.S., F.L.S. *Vice-Presidents:* Sir A. Geikie, D.Sc., LL.D., For.Sec.R.S.; G. J. Hinde, Ph.D.; Prof. J. W. Judd, F.R.S.; Henry Woodward, LL.D., F.R.S. *Secretaries:* J. E. Marr, Esq., M.A, F.R.S.; J. J. H. Teall, Esq., M.A., F.R.S. *Foreign Secretary.* J. W. Hulke, Esq., F.R.S. *Treasurer:* Prof. T. Wiltshire, M.A. F.L.S.

II.—February 22nd, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Microscopic Structure of the Wenlock Limestone, with Remarks on the Formation generally." By Edward Wethered, Esq.

Microscopic sections of limestone have been examined from May Hill, Purley, and Ledbury, and the exposures of Wenlock Limestone were visited by the author. As a result of their study, it appears that these limestones have been deposited under varying local conditions. At May Hill, the Wenlock Limestone shows three divisions:—at the base of the quarry a massive limestone, succeeded by thin-bedded limestones separated by shales, and above these a nodular, irregularly-bedded limestone. The limestone of this district shows abundance of granules similar to Oolitic ones, and it is marked by the occurrence of *Girvanella problematica,* with new and important forms of the genus *Girvanella.*

At Purley, near West Malvern, is a section somewhat similar to that at May Hill. Pisolite has been described from this area, and the author succeeded in finding a weathered block of limestone full of pisolites, whilst sections from the beds at the base of the quarry show them to be more or less oolitic. Amongst other *Girvanellæ,* a form occurs at Purley which has not been noticed at May Hill.

The Ledbury limestone is very different from those at May Hill and Purley. The variety of calcareous organisms which appear to have contributed to its formation is small. No sign of oolitic structure has been found here, and *Girvanella* is only represented by occasional aggregations of *G. problematica,* whilst the extraordinary number of forms obtained from May Hill and Purley shows in how great a measure the tubules of this organism have contributed to the formation of the limestones of those places.

The author at present offers no opinion as to whether *Girvanella* is animal or vegetable.

2. "On the Affinities of *Anthracoptera,* and of *Anthracomya.*" By Dr. Wheelton Hind, B.S., F.G.S.

In this paper the author gives the generic characters of the genera *Anthracoptera* and *Anthracomya,* and discusses their affinities. He gives reasons for supposing that the forms referable to these two genera lived in fresh water. The following species are described:—(i) *Anthracoptera modiolaris,* Sow., *A. triangularis,* Sow., *A. carinata,* Sow., *A. quadrata,* Sow., *A. tumida,* Eth. jun., *A. obesa,* Eth. jun., *A. elongata,* n.sp.; (ii) *Anthracomya Adamsi,* Salt., and var. *expansa,* Hind, *A. dolobrata,* Sow., *A. Phillipsii,* Williamson, *A. scotica,* Eth. jun., *A. modiolaris,* Salt., *A. elongata,* Williamson MS., *A.*

lanceolata, n.sp., *A. obtusa*, Ludwig, *A. angusta*, n.sp., *A. subcentralis*, Salt., *A. pumila*, Salt., *A. senex*, Salt., *A. obovata*, n.sp., *A.* n sp., *A. Wardi*, Salt. MS.

3. "Geological Remarks on certain Islands in the New Hebrides." By Lieut. G. C. Frederick, R.N. (Communicated by Sir Archibald Geikie, D.Sc., For.Sec.R.S., V.P.G.S.)

As far as can be judged from the soundings obtained, the New Hebrides are probably situated on a bank lying from 350 to 400 fathoms below the surface of the ocean and running in a N.N.W. and S.S.E. direction, with a deep valley between it and New Caledonia. The only two soundings obtained between these two groups are 2375 and 2730 fathoms, the former within a short distance of the New Hebrides.

Of the Islands, Tanna is volcanic—an active volcano, apparently consisting entirely of fragmental material, being situate on its eastern side. Efaté has some volcanic rock, but is chiefly of coral formation. It rises to a height of 2203 feet, and in some parts has a terraced appearance, the terraces denoting distinct periods of upheaval. Coral was found to the height of 1500 feet above sea-level. To the north of Efaté are Nguna, Pele, and Mau, of volcanic origin, and no coral has been found on them above sea-level; whilst Moso, Protection, and Errataka, to the west of Efaté, are of coral formation and similar in character to the adjoining coast of Efaté. In the vicinity of the coral isles is very little coral-reef, especially when the shores are steep. Delicate live corals were brought up from depths of 28, 39, and 42 fathoms off Moso, 37 fathoms near Mau, and 40 fathoms off Mataso. Mataso is a volcanic island with a narrow fringing-reef. Makura (six miles N. of Mataso) and Mai are also volcanic with narrow fringing-reefs partly surrounding the former and entirely encircling the latter island. A short distance west of Mai is Cook's Reef, of atoll formation. The Shepherd Isles are all of volcanic formation, apparently recent, and no coral was found growing around their shores. Mallicolo Island is of volcanic and coral formation. At one place in this island coral was found at a height of about 500 feet above sea-level.

III.—March 8th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

1. "On the Occurrence of Boulders and Pebbles from the Glacial Drift in gravels south of the Thames." By H. W. Monckton, Esq.

North of the Thames near London, the Glacial Drift consists largely of gravel, which is characterized by an abundance of pebbles of red quartzite and boulders of quartz and igneous rock. With the exception of very rare boulders of quartz, the hill and valley gravels of the greater part of Kent, Surrey, and Berkshire are entirely free from these materials. The author points out that the river Thames is not, however, the actual southern boundary of the distribution of these Glacial Drift pebbles and boulders, though the number of localities where they are found in gravels south of that river is few. The author describes or mentions several, of which the following are the most important:—Tilehurst, Reading, Sonning, Bisham at 351 feet above the sea, Maidenhead, Kingston, Wimbleton, and Dartford Heath.

2. "On the Plateau-Gravel south of Reading." By O. A. Shrubsole, Esq., F.G.S.

This paper contains observations on the gravel of the Easthampstead-Yately plateau. The constituent elements of the gravel are described, and the author notes pebbles of non-local material near Cæsar's Camp, Easthampstead, on the Finchampstead Ridges, and at Gallows Tree Pit at the summit of the Chobham Ridges plateau. He mentions instances of stones from the gravel of the plateau (described in the paper) which may bear marks of human workmanship. He furthermore argues that the inclusion of pebbles of non-local origin in the gravels may be due to submergence of the plateau up to a height of at least 400 feet above present sea-level, and cites other facts in support of this suggestion. He concludes that the precise age of the gravel can only be more or less of a guess, until the mode of its formation has been definitely ascertained.

3. "A Fossiliferous Pleistocene Deposit at Stone, on the Hampshire Coast." By Clement Reid, Esq., F.L.S., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

This is practically a supplement to a paper, "On the Pleistocene Deposits of the Sussex Coast," that appeared in the last volume of the Quarterly Journal. An equivalent of the mud-deposit of Selsey has now been discovered about 20 miles farther west, and from it have been obtained elephant-remains, and some mollusca and plants like those found at Selsey. Among the plants is a South European maple.

OBITUARY.

DR. OTTOMAR NOVAK.

BORN NOVEMBER 16TH, 1851. DIED JULY 29TH, 1892.

AN enthusiastic clear-minded student of Palæozoic fossils, including the Phyllocarids, in which the writers have been especially interested, has unfortunately passed away at the early age of 42. When last he wrote to one of us, in April, 1892, after his paper on the *Discinocaris Dusliana* had been published in the GEOL. MAG., he said "I am somewhat better this year and hope to recover completely during the summer." How sadly this hope was frustrated we know by his death in July of that year.

Dr. Ottomar Novák was Conservator of the Geological Collections in the Museum of Prague during the years 1885–6. He filled the chair of Geology in the University of Prague 1888–92, and was continuing the researches of the illustrious Barrande in the Silurian faunas of Bohemia at the time of his death.

The following is a list of some of the Scientific papers published by Dr. Novák:—

1. Remarques sur le Genre Aristozoë, Barrande (Sitzungsb. k. böhm. Gesell. Wissen. Jahrgang, 1885) showing that *Bactropus longipes*, Barrande, and *Ceratiocaris debilis*, Barr., constitute the abdominal segment and caudal appendage of *Aristozoë Regina*, Barr.
2. Nouveau Crustacé Phyllocaride de l'Etage F—f 2 en Bohême (Sitz. k. böhm. Ges. Wiss. Jahrg. 1885. Prag, 1885). *Ptychocaris simplex* and *Pt. parvula*.

3. Zur Kenntniss der Fauna der Etage F—f 1 in der palæozoischen Schichtengruppe Böhmens (Sitz. k. böhm. Ges. Wiss. Jahrg. 1886. Prag, 1886).
   Machæracanthus Bohemicus, Barrande, removed from *Ctenacanthus.*
   Added to the Faunal List, which is given in full, as consisting of 128 species:—
   Gyroceras Kayseri, nov. sp.
   Tentaculites acuarius, Richter.
   Hyolithes (*Orthotheca*) *intermedius*, nov. sp.
   Aristozoë solitaria, nov. sp.
   Ceratiocaris modesta, n. sp. MS.
   —— *Damesi*, n. sp. MS.
   Nautilus Alinæ, nov. sp., from Etage E—e 2, is also figured and described in the Appendix. The relationship of *Cryptocaris* to *Hyolithes*, as its operculum, is fully proved (see also Prof. Novák's Memoir on the Tentaculites of the Silurian strata of Bohemia in the Beiträge zur Paläontologie Osterreich-Ungarns, vol. ii. 1882.
4. Note sur Phasganocaris, nouveau Phyllocaride de l'Etage F—f 2, en Bohême. (Sitz. k. böhm. Ges. Wiss. Jahrg. 1886. Prag, 1886).
5. On the Occurrence of a new form of *Discinocaris* in the Graptolitic Beds of the "Colonie Haidinger" in Bohemia (Geol. Mag. Dec. III. Vol. IX. No. 334, August, 1892).

Most of Dr. Novák's valuable discoveries in the history of the Phyllocarids have been noticed in our Reports to the British Association. (See also Neues Jahrb. 1893, pp. 1–6.)

H. W. and T. R. J.

HENRY FRANCIS BLANFORD.

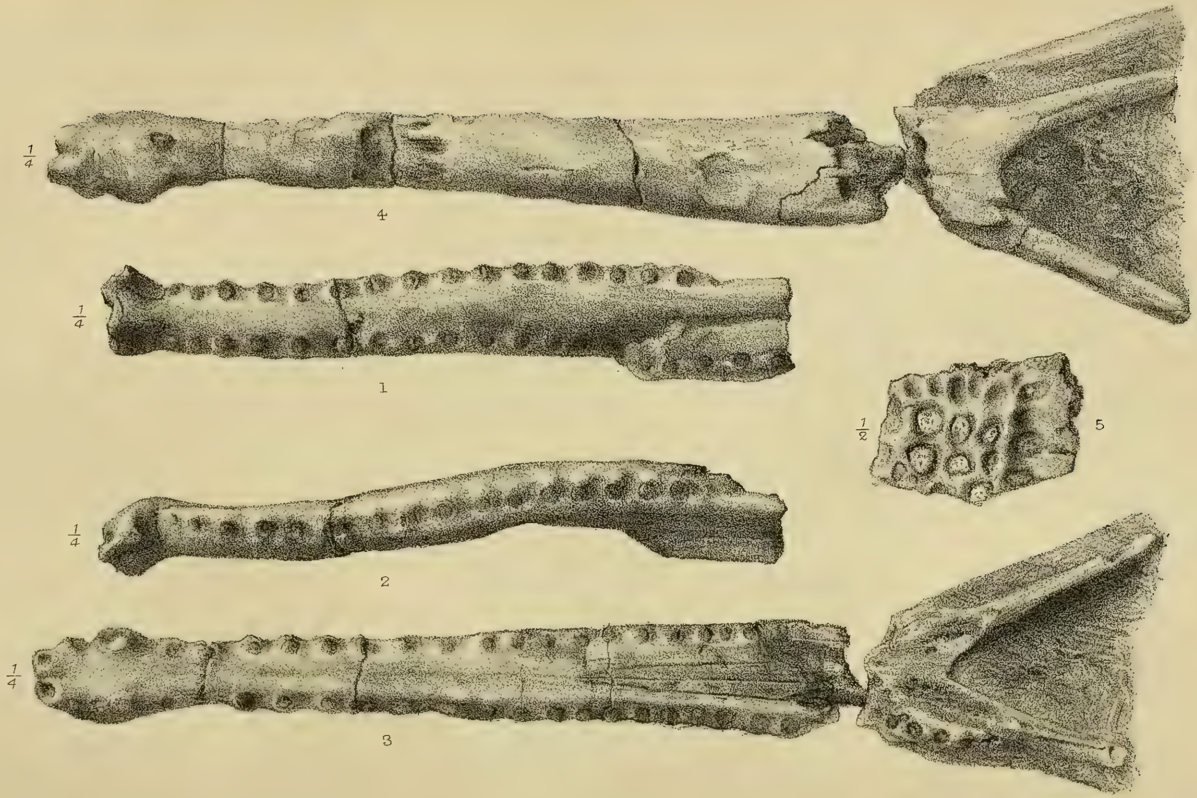
Henry Francis Blanford was born in 1834 in Bouverie Street, Whitefriars, where his father had a manufactory, now the "Daily News" Printing Office. His early education was obtained at private schools in Brighton and Brussels, and after studying for some time at the old School of Design in Somerset House he joined the Royal School of Mines at its first commencement in 1851, and a life that might otherwise very possibly have been devoted to art, for he was an admirable draughtsman, was thenceforward gained to science. At the Royal School of Mines he took the first place in his year, and received the Duke of Cornwall's Scholarship, then the only prize. After a year's study in Freiberg and another year in London, which he employed in preparing a translation of Scheerer's work on the blowpipe, his first publication, he was appointed to the staff of the Geological Survey of India together with his brother, Mr. W. T. Blanford, and landed in Calcutta at the end of September, 1855.

Almost immediately after their arrival in India, the two brothers and Mr. W. Theobald were despatched to examine and report upon an almost unknown Coalfield around Talchir in Orissa. The work done was chiefly memorable geologically for one discovery, that of the Talchir Boulder bed, and for the circumstance that, chiefly through Mr. H. F. Blanford's observations. the first step was taken towards the classification of the remarkable series of beds associated with the Indian Coal-bearing rocks, for both the underlying Talchir division and an overlying mass were separated from the Damuda or true Coal-bearing beds. For some time after this Mr. H. F. Blanford was engaged in Calcutta in charge of the Survey Office and was occupied with Palæontological work in the Museum; but in 1857 he was placed at the head of a strong survey party that was despatched to Madras, and he was chiefly engaged for the next three or four years in examining the Cretaceous beds near Trichinopoly and Pondicherry, some fossils from which, described by Prof. E. Forbes and Sir P. Egerton, had attracted much attention in Europe. The stratigraphical work on the Indian Cretaceous beds was mainly palæontological, but the classification established by Mr. Blanford was fully confirmed by Dr. F. Stoliczka's well-known description of the fauna. A commencement of this description was made by Mr. Blanford himself, who published an account of the Nautilidæ and Belemnitidæ in the "Palæontologia Indica" before he left the Survey in 1862. The geology of the area was described in a report published in the fourth volume of the Memoirs of the Geological Survey of India. An account of the geology of the Nilghiri Hills in the first volume of the same Memoir was the only other report on the Madras Presidency by Mr. Blanford published by the Survey.

The causes of Mr. Blanford's retirement from the Survey were partly injury to his health caused by exposure to the climate, partly strained personal relations with the Superintendent of the Survey, the late Dr. T. Oldham. After staying for a short time in Europe and recovering his health Mr. Blanford was appointed to the Science Professorship at the Presidency College, Calcutta, and was from 1864 to 1872 on the staff of the Bengal Educational Department. He became in 1864 one of the Hon. Secretaries of the Asiatic Society of Bengal, and about this time took up the subject of Indian Meteorology, at first in connection with cyclonic storms, of which a very severe one visited Calcutta in 1864. He was for some years a member of a Meteorological Committee appointed by the Government, but in 1867 he became Meteorological Reporter to the Government of Bengal, and finally in 1874, a new department having been formed by the Government of India, he was placed at the head. This post of Meteorological Reporter to the Government of India he held until his retirement from Indian service in 1888. After his retirement he resided at Folkestone until his death on January 23rd of the present year.

Besides a number of important reports and works on Meteorology, Mr. Blanford was author of several papers on fossil and recent Mollusca, and of two treatises on the geography of India. One of these has been used for many years as a text-book by schools and colleges in India; the other is a recent publication and forms one of Macmillan's geographical series, published under the editorship of Sir A. Geikie. Another recent publication of Mr. Blanford's is "A Practical Guide to the Climates and Weather of India, Ceylon, and Burma, and the Storms of Indian Seas." He also wrote, in conjunction with the late Mr. J. W. Salter, the Palæontology of Nitî. His only contribution to the Quarterly Journal of the Geological Society was an important paper published in 1875 on "The Age and Correlation of the Plant-bearing Series of India and the former existence of an Indo-Oceanic Continent."

Mr. H. F. Blanford became a Fellow of the Geological Society in 1862 and of the Royal Society in 1880. He was President of the Asiatic Society of Bengal in 1884–85.



E.C. & G.M. Woodward del et lith

West, Newman imp.

Steneosaurus Baroni, *R. B. Newton.*
Jurassic Rocks. Madagascar.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. V.—MAY, 1893.

ORIGINAL ARTICLES.

I.—On the Discovery of a Secondary Reptile in Madagascar: *Steneosaurus Baroni* (n. sp.); with a Reference to some Post-Tertiary Vertebrate Remains from the same Country recently acquired by the British Museum (Natural History).

By R. Bullen Newton, F.G.S.

(PLATE IX.)

THE Rev. Richard Baron, F.G.S., of the London Missionary Society, has sent to the British Museum some interesting reptilian remains from the Jurassic rocks of Madagascar, which he obtained during 1891, at Andranosamonta village, a locality situated in the north-western part of the Island. They were enclosed in a tenacious shelly limestone, so that before their examination could be proceeded with it was necessary to submit them to careful development and cleaning, a work which has been most ably carried out by Mr. Richard Hall, the Assistant Formatore of the Geological Department. The fragments thus relieved represent some of the more prominent parts of a skull belonging to the same animal, comprising:—

(1) An imperfect cranial rostrum, Pl. IX. Figs. 1 & 2.
(2) An almost complete mandible, Pl. IX. Figs. 3 & 4.
(3) Certain posterior parts of the cranium.

There is also a dermal scute, which although somewhat differently localized, *viz.* two miles south of Andranosamonta, is presumed to be a relic of this same reptile, Pl. IX. Fig. 5.

In glancing at the main features of this animal we note its possession of a narrow and elongate rostrum set with numerous alveoli, slightly differing in size, and having a more or less circular periphery.

The teeth are conical, obliquely set, and directed anteriorly; the base of one, showing through the lower surface of the mandible, exhibits a smooth carina on one of its exposed sides.

The premaxillæ unite to the maxillæ on the palatal surface by a well-marked rectangular suture, which terminates above in a deep posterior angle.

Among the chief characteristics of the mandible may be mentioned its long and narrow symphysis occupied by the splenial element, extending anteriorly to within 30 centimetres of the front.

The posterior portions of the head remaining in the matrix indicate a fairly well-defined occipital region consisting of an obtusely-angled quadrilateral supra-occipital, a transversely elliptical *foramen magnum,* and a tolerably extensive condyle, which is unfortunately imperfect and damaged through fracture.

The front view exhibits a strong parietal ridge, separating two large temporal fossæ, and having beneath a prominently arched pterygoidal vacuity.

The scute is thick, deeply pitted, with an imbricating end, which probably proves its relationship to the ventral armour. Its dimensions are 5·5 by 3·5 cent. with a thickness of 1·5 cent.

A consideration of these details proves conclusively that we are dealing with a reptile possessing Crocodilian affinities, and from its produced snout bearing a strong resemblance to the existing Gharial (*Gavialis*) of the Ganges, though differing very widely from it in other and more important characters. It is not till we go back much further in time that we find its congener among the Mesozoic Crocodiles forming the family of the Teleosauridæ. In comparing the generic peculiarities of this group, it is ascertained that in *Teleosaurus* the teeth are directed outwards, striated near the base, and without the two vertical carinæ; it has also a triangularly shaped supra-occipital. *Teleidosaurus* possesses a broad and short rostrum, few teeth, three dental alveoli only to each premaxilla, and a small circular occipital foramen and condyle.

In Geoffroy St. Hilaire's genus *Steneosaurus,*[1] as restricted by Deslongchamps[2] and adopted at the present day by Mr. R. Lydekker,[3] we recognize characters which will include the Malagasy specimen, *viz.* the presence of a long snout furnished with numerous bi-carinated teeth, obliquely set; a long, narrow, mandibular symphysis; extensive temporal fossæ; an obtusely quadrangular supra-occipital; and a transversely elliptical *foramen magnum.*

DESCRIPTION OF THE REMAINS.[4]

The *Cranial rostrum* is elongate, narrow, cylindrical and undulating; posterior end incomplete. It measures 37·5 centimetres in length, and graduates in width from 3·3 cent. at the præmaxillo-maxillary constriction to nearly 5 cent. at the fifteenth maxillary alveolus, with a section at the transverse fracture of 4 by 3 cent.

A fragment in the matrix, which probably represents the posterior extension of the maxillary region, has a length of 19 cent., and in immediate proximity to this is a long, slender, curved bone, which appears to be the quadrato-jugal, measuring 23·5 cent. These dimensions added together give 80 cent., or rather more than 2½ feet as the approximate extent of the entire cranium.

The right maxilla has 25 alveoli, including the six posterior ones, contained in the portion attached to the limestone; the left has 16 alveoli; therefore calculating 4 for each præmaxilla we may roughly assume that the total number of teeth for this animal was from 116 to 120.

---

[1] Mémoires du Muséum, Paris, 1825, vol. xii. p. 146.

[2] Notes Paléontologiques, 1867, p. 126.

[3] Catalogue Fossil Reptilia, British Museum, 1888, part i. p. 108.

[4] The author wishes to record his indebtedness to Mr. R. Lydekker, B.A., F.G.S., and to Mr. A. S. Woodward, F.G.S., for many valuable suggestions offered him during the preparation of this description.

The alveolar cavities are large, round, of a slightly varying diameter, and separated by wide and excavated interspaces which produce rather bold marginal serrations; the palatal surface lies just below the alveoli.

The præmaxillæ are swollen and truncated, but so mutilated in front that only the first and second alveoli are traceable on each side; the suture follows a rectangular course on the palatal surface, then passes closely by the first maxillary alveolus to continue its direction over the upper surface, where it makes a deep posterior descent and terminates in an acute angle.

At the transverse fracture of the rostrum the narial passage is observed to be cordiform in shape, with the apex pointing upwards; the obliquely set condition of the teeth can be also seen here.

The *Mandible* is long and narrow with a depressed dentary plateau, basal surface slightly convex and with vertical sides; it measures 62 centimetres in length, has a maximum thickness of 3 cent., and the posterior ends of the splenials are 13 cent. apart. The mandibular rostrum is widest at the 23rd alveolus where it measures 6 cent., gradually decreasing to half that width at the 6th and 7th alveoli. The dentaries dilate at the 3rd and 4th alveoli, afterwards tapering off to the part containing the two anterior sockets; a somewhat deep groove at the anterior end forms their dividing line.

The symphysis is elongate and narrow, its anterior point being distant 30 cent. from the front. The splenial bones are crushed in their central parts, but well defined anteriorly and posteriorly. Their divergent ends are embedded in the matrix.

The left dentary shows 26 alveoli, a few of the posterior ones being displaced and seen in the matrix; the alveoli similarly arranged as in the cranial rostrum, except the 3rd and 4th, which are contiguous and occupy the elevated and expanded region of the dentaries. The basal portion of the 3rd left dentary tooth is exposed on the under surface of the mandible and exhibits one of its lateral carinæ, which is smooth and not serrated.

The nutrient foramina are fairly distinguishable along the alveolar borders of both rostra.

CRANIAL REMAINS IN MATRIX.

These consist of the occipital region, considerably damaged in parts, having a central vertical depth of 10·5 cent., and a maximum width of about 24 cent.

The upper occipital is concave and quadrilateral, with obtuse angles possessing a similar depth and width of 3·7 cent. The *foramen magnum* is transversely elliptical, having a diameter of 4 by 1·4 cent.; the occipital condyle is large, with an imperfect and broken surface. To the right of the foramen is a distinct perforation, which probably marks the passage of the pneumo-gastric nerve. The extremities of the lower occipital through injury are difficult to define. The anterior view of this part of the cranium shows a strong parietal ridge, extending about 10 cent. and separating the large temporal fossæ, the front portions of which are absent; width of the right fossa is 7 cent.; height from the top of the parietal ridge to the pterygoidal vacuity is 9·5 cent.; this vacuity is strongly arched and measures at its greatest diameter 5·6 cent.

All other parts of the cranium, such as the orbits, frontals, nasals, palatines, etc., are unfortunately missing.

SPECIFIC AFFINITIES.

Comparing this specimen with some of the described species of *Steneosaurus,* we may observe that *S. Larteti* though of somewhat similar dimensions has a larger number of teeth, a straight cranial rostrum, and a rather more depressed head.

S. Stephani possesses more extensive temporal fossæ and larger alveoli.

S. megistorhynchus exhibits a much more extended and depressed cranium as well as more numerous teeth.

S. megarhinus differs in having five alveoli to each præmaxilla.

Not finding its exact representative among these various species, I propose to regard it as a new form, and this chiefly on account of its very narrow and cylindrical rostrum together with its marked undulation. The name proposed for the specimen is *Steneosaurus Baroni,* out of compliment to its discoverer.

The genus *Steneosaurus* has hitherto been restricted to British and European areas, so that the discovery of this reptile so far south as the Island of Madagascar is a matter of the highest interest when considering its geographical distribution. Sooner or later we shall hope to hear of its occurrence in the Jurassic rocks of the African continent, either in the neighbourhood of Mombasa or further northwards among the Antalo Limestones of Abyssinia.

Horizon.—As far as can be ascertained this genus has never been found out of Jurassic deposits. The few Molluscan shells associated with this new specimen tend to prove it of Lower Oolite age. These will be described elsewhere; in the meantime they may be referred to as (1) *Mytilus,* resembling *M. Tigrensis,* W. T. Blanford, from Abyssinia; (2) *Modiola,* similar in some characters to *M. imbricata,* Sowerby; (3) *Perna,* related to *P. quadrata,* Phillips; and (4) a new species of *Trochactæonina.*

EXPLANATION OF PLATE IX.

FIG. 1. *Steneosaurus Baroni,* sp. nov. Palatal view of the cranial rostrum.
,, 2. Left lateral aspect of the cranial rostrum showing its undulating character.
,, 3. Upper view of mandible, showing symphysis, splenials, etc.
,, 4. Basal view of mandible.
,, 5. Fragment of a dermal scute belonging to the ventral armour.

Figs. 1–4 are ¼ nat. size. Fig. 5 is ½ nat. size.

POST-TERTIARY VERTEBRATES FROM MADAGASCAR.

The British Museum has just acquired an interesting series of vertebrate remains from a Post-Tertiary deposit in Madagascar. They were obtained by the Rev. James Wills, another member of the London Missionary Society, at Sirabé, in the Province of Betsileo, which is marked on Dr. Mullen's[1] Map at 19·50′ S. and 47·10′ E. This locality lies in a region of extinct volcanic craters, and according to the maps has an elevation at this point of 4930 feet above sea-level. Thermal springs are also common in the neighbourhood; one at Betafo registering 130° Fahr.

The bones are of a dark brown colour and were found in a swampy deposit of a more or less peaty nature, probably forming the floor of the same dried-up ancient lake—mentioned by the Rev. R. Baron[2] as existing at this spot, and in which some years ago the late Dr. Hildebrandt[3] discovered the skull and skeleton of a Hippopotamus. These remains have been identified as follows:—

Crocodilus robustus, Grandidier and Vaillant.[4]
Æpyornis maximus, Geoffroy St. Hilaire.[5]
Hippopotamus Lemerlei, Grandidier and Milne Edwards.[6]

The same species of Crocodile[7] still abounds in the rivers of the country; but the Æpyornis and Hippopotamus are thought to be extinct, a view which may subsequently be disproved when more is ascertained concerning the unexplored parts of the island. The Hippopotamus bones indicate an animal of rather small dimensions, representing an intermediate form between the ordinary *H. amphibius* and *H. Liberiensis*, a pygmy species indigenous to the rivers of Western Africa.

It may be of interest to mention that sixty years ago Sir Roderick Murchison[8] announced to the Geological Society the discovery of a Hippopotamus tusk and molar tooth in a recent conglomerate rock from Madagascar.

No egg-shells were found associated with the Æpyornis bones, though their occurrence in the alluvial soil of the southern portions of the coast-line has long been recognized, some of them attaining to an enormous size. One example in the British Museum has a maximum circumference and girth of 36 and 30 inches respectively, with a liquid capacity of rather more than two gallons; it has been noticed by Capellini in the Mem. Acad. Inst. Bologna, 1889, ser. 4, vol. x. p. 16.

---

[1] On the Central Provinces of Madagascar, Journ. Roy. Geogr. Soc. 1875, vol. xlv. p. 139, map.

[2] Notes on the Geology of Madagascar, Q.J.G.S., 1889, vol. xlv. p. 308.

[3] Skizze zu einem Bilde central-Madagassischen Natur-lebens im Frühling. Zeitsch. Ges. Erdk. Berlin, 1881, vol. xvi. p. 194.

[4] Sur le crocodile fossile d'Amboulinsatre (Madagascar), Comptes Rendus, 1872, vol. lxxv. p. 150.

[5] Notice sur des ossements et des œufs trouvés à Madagascar dans des alluvions modernes et provenant d'un oiseau gigantesque, Ann. Sci. Nat. (Paris), 1850, ser. 3, vol. xiv. p. 206.

[6] Sur les découvertes zoologiques faites récemment à Madagascar par M. Alfred Grandidier, Comptes Rendus, 1868, vol. lxvii. p. 1165.

[7] G. A. Boulenger, Cat. Chelonians and Crocodiles in the British Museum, 1889, p. 286.

[8] Proc. Geol. Soc. Lond. 1833, vol. i. No. 31, p. 479. The specimen here referred to is in the Museum of the Geological Society, and is localised as 30 miles from Antananarivo (see MS. label).

Although relics of an exactly similar fauna have been made known from contemporaneous beds nearer the sea-border, particularly at Ambulisatra, on the south-west coast, considerable importance is to be attached to their occurrence inland, and in the centre of an extinct volcanic area. It must not, however, be forgotten that, as previously stated, Dr. Hildebrandt's discovery of 1881 will rank as the first record of vertebrate remains from this special locality.

Lastly, allusion may be made to the occurrence of Tortoise remains in the Quaternary deposits of Madagascar. Two finely-preserved carapaces of gigantic size have recently been added to the Geological Gallery of the British Museum. They were obtained by Mr. Last, off the south-west coast of the island, in a cavern two miles from the sea, where they were found embedded in a loose, sandy soil. Mr. G. A. Boulenger[1] has identified them as *Testudo Grandidieri*, Vaillant,[2] an extinct species most nearly allied to the existing *Testudo gigantea*, Schweigger,[3] of the Aldabra Islands, an uninhabited group to the north-west of Madagascar.

This comprises all the vertebrates at present known from the later Tertiary formations of Madagascar. There are, doubtless, many others yet to be disentombed, as the past fauna of this island could not possibly have been of so restricted a character as to consist merely of a Crocodile, a Tortoise, a Bird and a Mammal. Fresh discoveries are sure to follow on a more detailed investigation of these beds, and collectors would do well to remember that the history of *Æpyornis* still remains incomplete as the skull and other important parts of its skeleton are not yet known to science. It is hoped that the chiefs of the Malagasy tribes may place no impediments in the way of explorers who are endeavouring to obtain these buried relics relating to, so interesting a subject as, the extinct fauna of their country.

II.—ON SOME PALÆOZOIC PHYLLOPODOUS AND OTHER FOSSILS.

By Prof. T. RUPERT JONES, F.R.S. and Dr. HY. WOODWARD, F.R.S.

(PLATE X.)

SOME of this miscellaneous series of old fossils have been in the collections in the British Museum many years; but, owing to their small size and doubtful characters, they have not found an abiding place in any special zoological group.

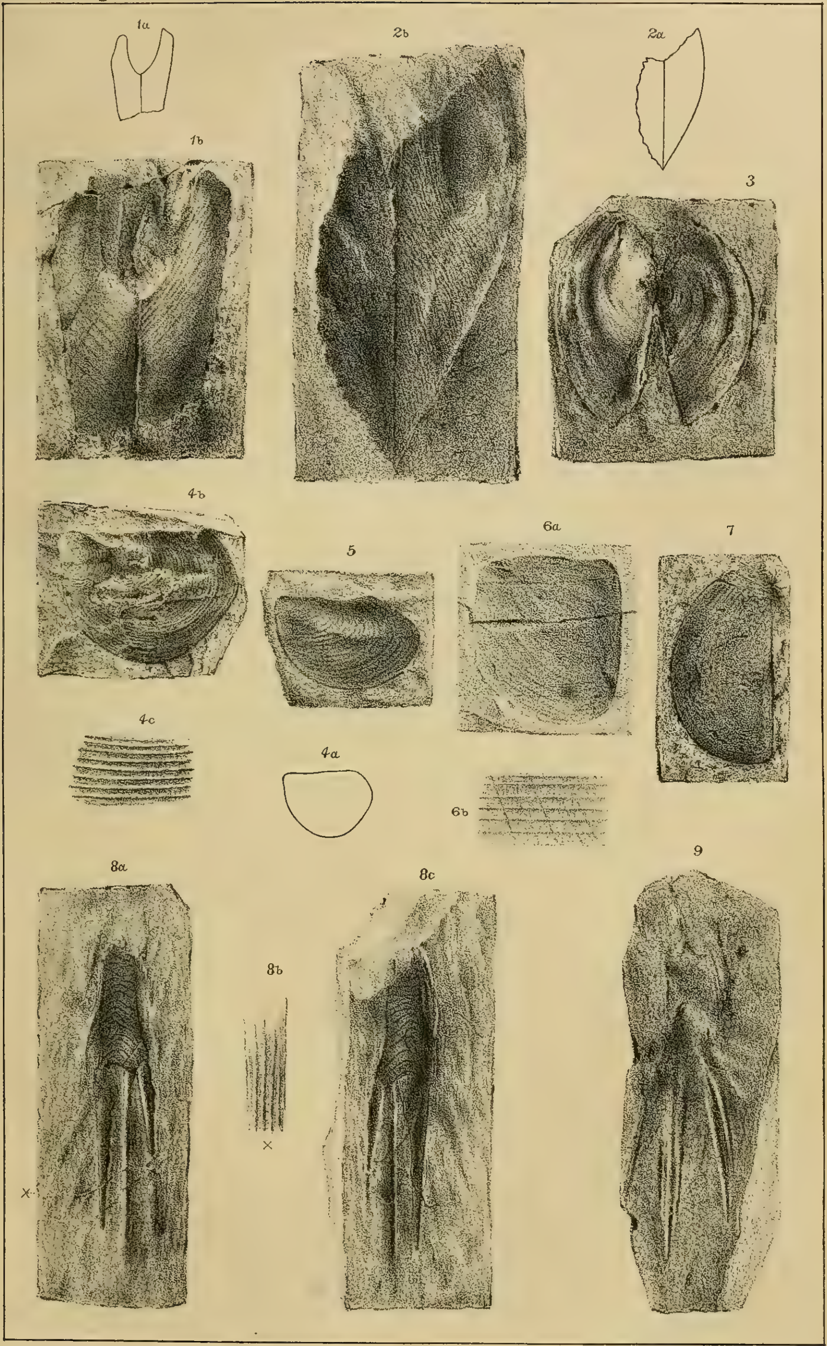
Others have been lately submitted to us for examination by Mr. G. J. Williams, F.G.S., of Blaenau Ffestiniog; and four of these have decidedly Phyllopodous or Phyllocaridal alliances.

---

[1] Proc. Zool. Soc. London, 1893, part 4, p. 581.

[2] Remarques complémentaires sur les Tortues gigantesques de Madagascar, Comptes Rendus, 1885, vol. c. p. 874.

[3] Prodromi monographiæ Cheloniorum, 1814, p. 58.



Geo. West & Sons del. lith. et imp.

PALÆOZOIC PHYLLOPODS &c.

Another specimen, belonging to the Woodwardian Museum at Cambridge, was long ago figured and described by the late Mr. J. W. Salter as probably belonging to a Ceratiocarid. Lastly, an enigmatical fossil, possibly belonging to one of the Crustacean groups, has been lent by the Owens College, Manchester, and is illustrated in the text.

1. PELTOCARIS SALTERIANA, sp. nov. Plate X. Figs. 1*a*, 1*b*.

This specimen shows two imperfect valves, lying in contact along the dorsal sulcus, with a deep semi-oval nuchal notch; and in these features corresponding with the genus *Peltocaris*. The surface-ornament consists of strongly-marked subconcentric striæ, oblique, form in front backwards and inwards, on each valve; and much wider apart on the left valve than on the other, possibly from the loss of one or more layers of the test.

Each valve is partially imbedded at the ends and on the edges; and the left valve is broken in front. Pieces of the broken test roughen the nuchal space. As this differs from any species which we know, both as to shape and the obliquity of the lines of growth, we propose to distinguish it as *Peltocaris Salteriana,* thus naming it after the original founder of the genus.

Fig. 1 is one of the two counterparts, which are dark films of a fragmentary carapace, 11 mm. long and 7 mm. wide, in hard dark-grey shale of the Lower Tremadoc series. From a small quarry on the stream flowing North from Moel Llyfnant, seven miles E.S.E. of Ffestiniog. Mr. G. J. Williams' Collection.

2. CONULARIA (fragment). Plate X. Figs. 2*a*, 2*b*.

This obscure specimen has, at first sight, the appearance of two imperfect valves or moieties of an *Aptychopsis,* very acute posteriorly, and retaining the attenuated posterior extremity of a nuchal notch, at the front end of a dorsal suture. The superficial ornament, however, is not at all concentric, but almost uniformly oblique across the two moieties of the fossil, and bending in at the central line. This sculpturing seems to agree with the markings on the two sides of a small imperfectly preserved *Conularia.* The greatest length of the relic is 18 mm. and the width 9 mm.

Fig. 2 is a dark film, on hard dark-grey shale, weathering reddish on one face, from Llechwedd Deiliog quarry, about six miles East of Ffestiniog, on the Ffestiniog-Bala road. Arenig formation. Mr. G. J. Williams' Collection.

3. DIPTEROCARIS ETHERIDGEI, T. R. J. and H. W. Pl. X. Fig. 3.

Peltocaris (?), sp. ind., Nicholson and Etheridge. Monograph Silur. Foss. Girvan District, Ayrshire, vol. i. 1880, p. 212, pl. 14, fig. 21.

Dipterocaris Etheridgei, T. R. J. and H. W. GEOL. MAG. 1884, pp. 349 and 353; Brit. Assoc. Report for 1884 (1885), pp. 75, 78, and 85.

This little fossil (Fig. 3) shows two "alæ," or wing-like moieties, not sutured[1] together at their narrow junction, nearly semi-circular on the outer edge, and on the inside bounded by oblique edges, two (below) meeting near the centre at an angle of about 25°, and two (above) at an angle of 60°.

---

[1] "Anchylosed and without hingement," in Mr. J. M. Clarke's well-preserved specimens described and figured in the "Amer. Journ. Sci. ser. 3, vol. xxv. p. 121.

This differs but little from the last-mentioned specimen, found in the Penwhapple Burn, Girvan, except in being larger and more symmetrical—that is, less distorted. Hence the two appear to belong to one and the same species; and their geological stages are not very far apart, for the Girvan species came from the Penkill Beds, as mentioned in the Table at pp. 235–6 of the "Monograph" alluded to above, which are referred to the "lower part of the Upper Silurian,"—that is, to the "Upper Llandovery or May Hill Sandstone," see page 227 of the "Monograph."

This form is similar in essential particulars to Mr. J. M. Clarke's Devonian *Dipterocaris pennæ-Dædali* (*op. cit.* p. 123, fig. 1); but differs from it in the two *alæ*, taken together, having a rounded outline, and the posterior cleft is not so widely open. The British form is also much smaller. From *D. Procue*, Clarke, and *D. pes-cervæ*, Clarke, it differs still more in several respects.

Fig. 3 is a dark film, slightly thickened, and whiter on the outer curve of each valve, and at each end of the left valve; it also has some ferruginous thickenings at the centre and elsewhere. On a hard dark-grey shale, of Upper Silurian (Salopian) age, from Penyglog quarry, Corwen, on the border of Counties Merioneth and Denbigh, North Wales, Mr. G. J. Williams' collection.

		Left *ala* of the Girvan specimen according to the figure.
Greatest length of the right-hand moiety or *ala* ...	28 mm.	... 12 mm.
Greatest width ,, ,, ,, ...	12 ,,	... 4½ ,,
Length of the posterior cleft or notch	15 ,,	... 6 ,,
Length of the anterior ,, ,, ... about	6 ,,	... 4½ ,,
Median junctural interval ... ... about	6 ,,	... 1 ,,

4. Mytiloid Shells. Plate X. Figs. 4*a*, *b*, *c*, and 5.

These were selected some time ago as having an Estherioid appearance; but, under the microscope, the evidence of such an alliance disappears. Our Figs. 4 and 5 approximate to some of the Silurian *Mytili* described and figured by Barrande in his "Syst. Silur. Bohême," vol. vi. such as pl. 210, figs. 1, 4, 5, and 6, *M. consors*, and fig. VI. 6, *M. longior*.

Figs. 4*a*, *b*, *c*, represent a black film, somewhat crumpled and broken on the upper edge; it shows very delicate concentric lines of growth. On a hard black shale; British Museum, No. 48762; without a locality; from the "Bright Collection."

The valve is 6 mm. long, and 4 mm. high.

Fig. 5. A black film on dark-grey, hard shale, with ferruginous face. A small portion of the shell or test remains at the apex. British Museum, No. I. 2612. Probably from the Tremadoc Slates; no locality.

The valve is 20 mm. long, and 12 mm. high.

The junction is obscure in the figure given of the similar fossil in Nicholson and Etheridge's "Monograph of the Silurian Fossils of the Girvan District in Ayrshire," vol. i. 1880, p. 212, pl. 14, fig. 21.

5. Fragments of a Phyllocarid ? Plate X. Figs. 6*a*, 6*b*.

This was selected as being possibly an imperfect valve or moiety of a Phyllopodous carapace; but we find that the evidences of its alliance in any direction are too poor to allow of critical determination. Mr. J. W. Salter labelled it "*Lingula*," possibly with the view of its being an imperfect triangular shell, the upper right-hand corner in Fig. 6*a* being regarded as at or near the umbo; the striæ, however, are not really concentric with that angle. Some effects of lateral pressure are seen in the oblique parallel lines crossing the lines of growth in Fig. 6*b*.

Fig. 6 is a black film on black shale, from the Lowest Llandeilo beds at Abereiddy Bay, Cardiganshire. British Museum, No. I. 2611.

6. Aptychopsis Williamsii, sp. nov. Plate X. Fig. 7.

This is the moiety of a carapace near to those of *Aptychopsis ovata*,[1] J. & W., and *A. Wilsoni*,[2] H. W., but differing from each in the curve of the outer edge, and in the proportion and angle of the nuchal notch. In particular, this valve has a relatively fuller curve posteriorly, and is narrower in the upper part, than either of those above-mentioned. The uppermost edge has been somewhat damaged, like our figure of *A. Salteri*, H. W.[3]

At first sight, when looked at with its straight edge uppermost, this simulates a valve of *Ceratiocaris Ruthveniana*[4] with a broken anterior end; the striate ornament, however, consists of concentric, and not longitudinal, lines, and the posterior extremity is more angular. We name it in honour of its discoverer, Mr. G. J. Williams of Blaenau Ffestiniog.

Fig. 7 represents a dark film in dark-grey, rather hard shale, from Harp Hollow near Welspool, of Upper-Silurian age. Mr. G. J. Williams' Collection.

Left valve—Length, 26 mm.; Width, 13 mm.; Depth of notch, about 5 mm.; Length of dorsal suture, 22 mm.

The nuchal notch opens at an angle of about 120°.

7. Ceratiocaris insperata, Salter. Plate X. Figs. 8*a*, *b*, *c*, and 9.

Ceratiocaris ? insperatus, Salter, Mem. Geol. Surv. vol. iii, 1866, p. 295, woodcut, fig. 6; 2nd edit. 1881, p. 486, woodcut, fig. 6.
——— ——— —— In "Siluria," 3rd (4th) edit. 1867, p. 516.
——— ——— —— Catal. C. S. Foss. Cambridge, 1873, p. 16.
——— ——— H. Woodward, Catal. Brit. Foss. Crust. 1877, p. 71.
——— *insperata*, T. R. J. and H. W., Geol. Mag. 1885, p. 466; Brit. Assoc. Report for 1885 (1886), p. 351.
——— ——— ——— Monograph Brit. Palæoz. Phyllop. part i. 1888, p. 64.
——— ——— H. Woods. Catal. Type Foss. Woodw. Mus. Cambridge, 1891, p. 134.

Fig. 8, in a fairly good state of preservation, shows three caudal spines (one style and two stylets), and the distal portion of a sub-

---

[1] Monograph Brit. Palæoz. Phyllop. part ii. 1892, p. 108, pl. 15, figs. 4 and 5.
[2] *Ibid.* p. 105, pl. 15, figs. 12, 15 and 16.
[3] *Ibid.* pl. 17, fig. 6.
[4] *Ibid.* part i. 1888, p. 49, pl. 10, fig. 6.

cylindrical telson, or last abdominal segment. This has left a strong, black, shining film, bearing irregular chevron-like marks, with their angles pointing upwards. These have some resemblance to the ornamentation of the style of *Phasganocaris pugio* (Barrande), as figured by Novák in the Sitzsb. böhm. Gesell. Wissen. 1886, pl. 1, figs. 5, 7, 12, and 14; but the telson of that species has the leaf-like ornament present on some of the *Ceratiocarides*, and not the angular striation of the present form (fig. 8).

The longest or middle spine is bulbous at the top, fitting into the end of the telson; and the two stylets appear to be articulated to the lateral angles, where the end of the telson widens out. The longitudinal striæ (fig. 8*b*.), such as one of these two lateral spines exhibits, may have characterized the others; and the central spine (style) seems to have been strongly ridged along its median line.

As far as the materials serve, we think that fig. 8 may well be of the same genus and species as fig. 9 (*C. insperata*).

Fig. 8*a* and *b*, two counterparts (natural size), black shining films, on hard dark-grey shale, of the Arenig series, from Llechwedd Deiliog quarry, about six miles E. of Ffestiniog.

Greatest length of specimen, 41 mm. Length of the fragment of the last abdominal segment, 16 mm. Greatest width of the last abdominal segment (at its distal end), 7 mm. Least width (at the proximal end of the fragment), 4 mm. Length of one stylet, 22·5 mm. Length of the other, not so well exposed, 21 mm. Length of the style (middle spine), 26 mm.; width at its head (proximal end), 4 mm.

The obscure appearances of other lateral spines, in fig. 8*a*, are quite adventitious, being due to the irregular surface of the shale, as seen more clearly in fig. 8*c*.

Fig. 9 is a careful illustration of the fossil described and figured by Salter, and preserved in the Woodwardian Museum at Cambridge. The trifid caudal appendage is clearly shown in the natural impression; and two at least of the spines appear to have been ridged or fluted. The telson is obscurely indicated.

Fig. 10. An impression or cast (natural size) in dark-grey hard shale from the Upper-Tremadoc series, at the railway-cutting above Penmorfa, Portmadoc. Collected by Mr. D. Humfrey.

Middle spine (style), 28 mm. long. Outside spines (stylets), about 18 mm. long. Width of the end of the telson, about 7 mm.

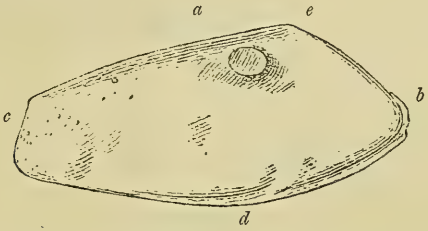
---

8. The subtrigonal, probably crustacean, test here figured came from the Upper Silurian beds at Church Hill, Leintwardine, near Ludlow, and is preserved in the Owens College Museum, Manchester.

Length of the fossil, 53 mm.; its greatest width, 23 mm.; its least width, 10 mm.

Taking the straight edge (*a*) as indicating a dorsal border at top, we see that each end of the fossil has a sloping edge,—one (*b*) much longer, and sloping at a lower angle (45°) than the short steep slope (*c*) at the other end (60°). This last turns rapidly to the third border (*d*), which swells out with a broad curve to meet the other sloping edge (*b*) first mentioned. Near the angle (*e*), between the last mentioned and the straight edge, is a round spot, which may have been the base of a large prickle or outstanding spine; and the surface of the other (narrower) part of the test is besprinkled with minute spots, which may have been the bases of small prickles.

If looked at as being possibly the valve of a *Ceratiocaris*, it does not agree in outline and features with any known species, and its markings are foreign to that genus. The only approximate analogue is the somewhat apocryphal figures or diagrams in "Siluria," 1857, p. 262, Fossils (65), 1 and 2, with which we cannot as yet collate exactly any specimens.



Another, but even more doubtful analogue, may be perhaps seen in the outline of A. S. Packard's *Cryptozoë problematica*, Proceed. Amer. Phil. Soc. vol. xxiii. 1886, p. 380, fig. 1.

If our specimen be placed with the slope, *e*, *b*, upwards, it might possibly be regarded as the right valve of an *Aptychopsis* were it not that the lower edge, *c*, would form one side of a posterior notch strange to that genus, and the surface-marks would also be abnormal.

Some such posterior notch exists in *Dipterocaris* and its allies; but the moieties or alæ of their carapaces not being sutured, coalesce at the junction.

We must therefore leave this interesting, but enigmatical, fossil to some future investigation before we can decide upon its characters and alliance.

DESCRIPTION OF PLATE X.

Fig. 1. *Peltocaris Salteriana*, sp. nov., *a*, natural size; *b*, magnified 3 diameters.
,, 2. Fragment of a *Conularia*, *a*, nat. size; *b*, magn. 3 diam.
,, 3. *Dipterocaris Etheridgei*, T. R. J. and H. W., nat. size.
,, 4. Mytiloid shell, *a*, nat. size; *b*, magn. 2 diam.; *c*, ornament, magn. 15 diam.
,, 5. Mytiloid shell, natural size.
,, 6. Fragment of a Phyllocarid? *a*, nat. size; *b*, ornament, magn. 15 diam.
,, 7. *Aptychopsis Williamsii*, sp. nov. Left valve; nat. size.
,, 8. *Ceratiocaris insperata*, Salter. Two counterparts, *a* and *c*, nat. size; *b*, ornament on one of the stylets, magn. 3 diam.
,, 9. *Ceratiocaris insperata*, Salter. Impression; nat. size.

III.—ON SOME QUARTZ-SCHISTS FROM THE ALPS.

By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., F.G.S.

A THICK mass of bedded schists, as I have described in more than one paper,[1] occupies the highest position among the so-called metamorphic rocks of the Alps. With the exception of some gneisses—so far as I know of a porphyritic character, and almost certainly intrusive granites modified by pressure—and various green schists, which, in part at least, are basic igneous rocks, similarly affected,[2] the group, which may be traced from one end of the chain to the other, consists of altered sediments. Calcareous mica-schists are its most abundant members. The commonest types are dark schists varying from lead colour to black (the *Thon-schiefer* or *Thon-glimmer-schiefer* of many Continental authors) from which the calcite sometimes disappears, and greyish schists in which there is not much mica (the *kalkhaltig glimmer-schiefer* of the same, which locally becomes a white marble[3]). Quartz-schists also occur, sometimes merely as laminæ alternating with the darker mica-schists—like sand and clay in certain stratified rocks—sometimes in beds. These, so far as I know, are of moderate thickness and white in colour.

That the various schists are associated exactly as are shales, limestones, and sands in ordinary stratified masses cannot, I think, be doubted.[4] The persistence of lithological types over large areas is often remarkable; even the peculiar black mica-schist with dark garnets can be traced, to my knowledge, for more than thirty miles along the general strike of the group.[5] Still changes occur, especially in the transverse direction. The group of dark-coloured mica-schist, of which the above-named garnet-bearing rock is a member, occupies a broad strip for some miles E.N.E of Monte Leone, but for a considerable distance west of that mountain the rocks become lighter in colour, and the darker type is restricted to the northern margin. We perceive the change if we ascend towards the Simplon Pass from the Rhone Valley; it is even more marked, if we extend our examination up the Vispthal as far as the outlying masses of the same group near the range of Monte Rosa.

The quartz-schists, so far as I know, are not always present and are generally of subordinate importance. But they occur at intervals over a considerable part of the chain. My collection contains specimens from the neighbourhood of Windisch Matrey (*i.e.* very near the Gross Glockner) to the district of the Great St. Bernard.[6] But I purpose to restrict my description mainly to the quartz-schists which occur in the neighbourhood of Saas-Fee, since here I have studied them in more detail. In this neighbourhood the calc-mica-schist group is obviously folded up in a very complicated fashion between the underlying gneissose rocks.[1] The gigantic undulations rise and fall for thousands of feet. It is no exaggeration to say that an active climber in a single day might touch the schists at points separated by a mile vertical. I know of outcrops on the same path which differ in elevation by full 3000 feet.[2] But to describe in detail either these folds or the varieties of the calc-mica-schists[3] would occupy too much space; on the present occasion I must restrict myself to the quartz-schists.

---

[1] Q.J.G.S. vol. xlii. (Presid. Address) xlv. p. 67; vol. xlvi. p. 187.

[2] Q.J.G.S. vol. xlix. p. 94.

[3] Sometimes dolomitic.

[4] I have examined them more or less minutely, over various Alpine regions, from the Viso to the Gross-Glockner.

[5] Q.J.G.S. vol. xlvi. p. 199, etc.

[6] I have not been east of the former among the crystalline schists, nor found them west of the latter in any journey made since I began to pay minute attention to the Alpine schists.

This is a rock macroscopically very well characterized. It is a compact white quartz-rock,[4] containing a variable quantity of silvery mica, which is sometimes grey coloured. The latter mineral not seldom is almost absent from bands an inch or so thick; then it may become abundant, forming sometimes a layer hardly thicker than a sheet of letter paper, sometimes distinct bands in thickness, running up to about half an inch (seldom reaching one inch), when the rock, strictly speaking, consists of alternating layers of white quartz-schist and lead-grey or greenish-grey mica-schist. In weathering it shows a marked tendency to break up into slabs. This, for instance, is very conspicuous in the quartz-schists which crop out on the craggy slopes west of the hotels at Saas-Fee. The talus below is strewn with slabs about as thick as the tiles used in flooring an outhouse. The laminæ of mica determine their separation, so that the surface sparkles with little scattered flakes of this mineral, and the thicker blocks may be further split up with the hammer. The basset edges of the rock can be recognized at once by their peculiar "flaggy" aspect and sharp, almost rectangular, jointing. In this section, as usual, the quartz-schist is associated with varieties of the calc-mica-schist, in which the mica is generally subordinated as much as in the quartz-schist. The change from the one rock to the other is rapid, but the calc-schist is often more micaceous in the immediate vicinity of the quartz-schist. The former becomes in places an almost pure marble; sometimes also it is quite "slaty," fine-grained, crumbling, and of a bluish-grey colour, at first sight very like some of the Mesozoic limestones of the Alps. The resemblance is the result of pressure;[5] the real difference becomes apparent on careful examination.

The general relations of these schists are readily determined, but some minor questions are by no means easy to settle. It is quite clear that the mass, as a whole, is infolded between moderately coarse rather micaceous gneiss, of a type common in the district. The latter, often considerably crushed, may be seen cropping out in places both below and above, extending in the latter direction right up to the mountain crests;[1] but it is difficult to ascertain the exact nature of the fold. In one place—just west of the hotels—we found only two outcrops of the quartz-schists; but further away to the south (working towards the shoulder overlooking the stream from the Hochbalm Glacier) two other bands of quartz-schists made their appearance, one seemingly above and one below the higher of the former outcrops. Have we here a double fold or are some other beds intercalated? There is something to be said for each view, and as the matter is of little moment I did not attempt to work it out in detail.[2] On the opposite side of the above-named stream we find, at the base of the mountain-buttress corresponding with the one just described (in descending order), calc-mica-schist, and below this two bands of quartz-schist, the higher about 10 feet, the lower about 8 feet thick, separated by about 3 feet of calc-mica-schist, very micaceous in lower part, saccharoidal, with thin mica-layers, in upper. As the bands of quartz-schist mentioned in the previous description at least are many yards apart, one of them (probably the highest)[3] appears to be locally split up by a calcareous band; lower down, after some more calc-mica-schist, is another band of quartz-schist. The same rocks also occur on the Fee-Gletscher alp—further to the south-west.

---

[1] It was my intention to give some particulars of these gneisses, but they would make the article too long, so I reserve them for a future communication.

[2] Between Saas-Fee and Saas im-Grund and on the peak of the Mittaghorn.

[3] Many details are given in the papers to which reference has already been made.

[4] I avoid the term quartzite for reasons which will presently appear.

[5] Other instances may be found both in this district and elsewhere in the Alps. The effect of pressure in crystalline limestones is discussed in this Magazine, 1889, p. 483.

Another section occurs on the opposite side of the valley in which Saas-Fee stands, which requires some description. This is on the north-eastern part of the Mittaghorn.[4] Here we found in one place the quartz-schist separated from the gneiss by a fairly thick zone of calc-mica-schist; the latter then thins gradually out (as the path *descends*) till the quartz-schist is in contact with the gneiss. After this has happened the quartz-schist is thrown into S-like curves, and in one place a mass of calc-schist only a few feet thick remains infolded in the top part of the letter. The quartz-schist in contact with the gneiss is micaceous, contains some elongated spots like a felspar, and seems as if it passed rapidly into the gneiss, which is somewhat affected by pressure, is not a coarse-grained variety, and contains (in larger amount) a similar mica. The annexed section may serve to make the relation clearer. Evidently the quartz-schist is unconformable with the gneiss, so the question to be determined is whether the latter is an older rock than the former, or is an intrusive granite which has been afterwards crushed into a gneiss. The quartz-schist certainly becomes more micaceous as it approaches the gneiss, and I thought that here and there I could detect in it indications of larger quartz grains.

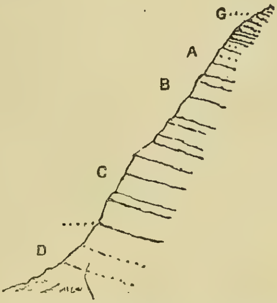
---

[1] It is indicated as correctly as the scale permits on the Swiss map, sheet xxiii. Here the gneiss above is distinguished from that below. There are some differences, but I think that we may regard them as of minor importance, and the gneiss broadly as one group.

[2] To give an idea of the possible complication I may mention that in one place we found a small patch of a cavernous, yellowish, soft, calcareous rock, containing numerous fragments from the calc-schist group. It *might* have been a tufa; but the position made this interpretation improbable, and I strongly suspect it was the last remains of an infold of rauchwacke (Trias). This rock is mapped as here and there in the middle of the crystallines in this part of the Pennines, always in mere strips, and with the once overlying Jurassic rocks wholly gone.

[3] I refer only to the *apparent* position.

[4] The path from Saas-Fee ascends and crosses the northern spur of the Mittaghorn and then runs for some little time along the eastern face at a height probably of rather more than 3000 feet above the Saas-thal. The sections described are found soon after the corner is turned, but the calc-mica-schist and quartz-schist can be also seen for some distance running obliquely down the western slope of the mountain.



G Gneiss.

A Gneissose Quartz-schist (?)

B} C} Quartz-schist.

D Calc-schist.

G seems to quadrate in A and A into B the last and C are varieties of quartz-schist and certainly pass one into the other; the passage from C to D about the dotted line is quick.

Specimens were secured for microscopic examination, which may be now described. It will be convenient to take first the normal quartz-schist, such as occurs at c in the section, and with this specimens of similar rock from other localities may be included. These flaggy quartz-schists consist almost entirely of quartz and mica, with an occasional grain of felspar, which, however, is sometimes all but absent.[1] The quartz grains vary in size in the different specimens, but are commonly less than ·02″. Usually they are distinctly longer in the direction of the foliation, their outline is irregular, sometimes ragged, giving a characteristic "clotted" look; occasionally, if the nicols be used, one tint, especially where the grains run small, seems to predominate in the slide. No trace of a nucleus can be detected in the grains, which exhibit the peculiar mosaic structure often seen in the more quartzose layers of the mica-schists of the same group. Minute fluid cavities with relatively small bubbles are rather numerous.[2] They are more abundant near, but not restricted to, the junction of grains. The mica flakes range from about ·04″ downwards in length, being frequently about ·03″, though in some slides smaller scales, say about ·01″, are common. With transmitted light, they vary from a slightly olive-grey to colourless. Dichroism, if any, is very faint; they are, in the former case, a little greener with vibrations parallel to the basal plane. The ends are often rather irregular, but sometimes the flakes are a little lenticular in outline, as if slightly nipped. In a specimen from the south side of the Lukmannier Pass, where thin laminæ of mica alternate repeatedly with layers of quartz, and the rock macroscopically shows beautiful flexures, it is clear that the folding took place after the foliation had been produced. The grains of felspar are often a little larger than the quartz, but of the same general form. As a rule they are more or less decomposed, but not seldom are in fair preservation, showing characteristic twinning, etc.

---

[1] Small zircons, occasional grains of iron oxide, probably also of zoisite, may be detected, but on these it is needless to dwell, as they have no apparent bearing on the history of the rock.

[2] Most of these require a one-eighth objective and many can only just be seen with that; some are irregular in form, the majority oval.

In regard to the other specimens collected from the Mittaghorn; two were taken respectively 6 feet and 10 feet from the one already mentioned; the second near to the seeming passage of the quartz-schist into the gneiss. They are more micaceous than the former one, and the first is rather gneissic in aspect, as if some felspar were present. On microscopic examination that proves to be the case. The felspar grains, far from numerous, are irregular in outline like the quartz, and are rather decomposed. Two or three of them are about ·07″ in diameter, while the quartz grains seldom exceed and are often less than ·01″. The second specimen only differs from that already described in being distinctly more micaceous, and in having its quartz grains a shade smaller. In this but little felspar is recognizable though a disseminated brown dust gives the slide a less clear aspect. A fourth specimen was taken at a distance of about 100 yards, very close to the junction with the gneiss; the precise line of demarcation, as already said, being impossible to determine.[1] Here the constituents are decidedly more variable in size. Much of the mica (abundant) is about as large as that in the other slides, but there are many flakes barely ·01″ long. The quartz is occasionally about the same diameter, but as a rule is much smaller. Very little felspar can be recognized, but occasional clouds of brown dust suggest that it may have been present, and the slide as a whole is dirty.[2]

Next as to the relation between the present structure and the pressure which these rocks have undoubtedly undergone. In the cases under immediate consideration, the fissility and the foliation are parallel to the banded structure, so the modifying pressure must have acted at right angles to it. The constituents of the rock do not suggest shearing forces of importance, nor indeed so much "flattening out" as one would anticipate. In some cases no doubt a peculiar clotting and mixing of grains and granules may indicate something of the kind; but in these specimens from the Saas-thal only a moderate amount of mechanical disturbance is suggested. The condition of schists which belong to the same group and occur as fragments in the Rauchwacke (Trias) indicates that the foliation was anterior to the Tertiary mountain-making, so that in all probability these rocks had very nearly arrived at their present condition prior to Mesozoic times, and the uprearing of the present Alpine chain only rendered them more fissile and produced occasional flexures.

---

[1] Thus labelled in the field: "seems to be the base of the quartz-schist, just against wrinkled gneiss."

[2] In these slides a few rather irregular grains of a clear mineral are present, which is probably zoisite, and in one garnet (one or two grains of rather fragmental aspect) is probably present.

But in none of these quartz-schists can original fragments be distinguished with certainty. Here and there a clastic structure may be suspected. Here and there an inequality in size may suggest that the larger quartzes either are not authigenous or, if so in a certain sense, only represent the remains of grains which have escaped better than the rest in a general catastrophe. There is nothing to intimate that the mica in its present form is derivative. Like the quartz, it seems either to have formed or at least to have acquired its present outline *in situ.*[1] The few grains of felspar in one specimen most nearly resemble fragments. I cannot detect any structural difference, allowing for the altered proportion of the constituents, between these quartz-schists and some of the mica-schists, such as are found in the same group, and the latter correspond more nearly (though by no means identical) with certain laminated sediments altered by contact metamorphism [2] than with any other rocks known to me.

But these quartz-schists are markedly different from ordinary quartzites.[3] In these either the original sand-grains, though surrounded by an aureole of secondary quartz, can be readily recognized, or the comparatively regular granular structure suggests a clastic origin. So too does the mica, when it occurs. No marked reconstitution of constituents has taken place. A felspar fragment still remains as a fragment; rotten perhaps, but not, as it were, inosculating with a mosaic of quartz and white mica. These quartzites, also even after being subjected to pressure, do not put on, so far as I know, the aspect of *quartz-schists*[4]—in the former the fragmental character of the rock, the cause of its modified structure, are at once apparent. Not so in the quartz-schists; that they were once sandstone, though doubtless true, is only a matter of conjecture; how far they have been affected by pressure is a matter of uncertainty.[5]

---

[1] The structure of these schists sometimes recalls that of certain of the rocks on the Eastern Gneiss near Kinlochewe, but the structure is coarser, the fragmental character (due in the latter to crushing) is less distinct, as if mineral reconstitution had been more complete in these Alpine rocks.

[2] See Q.J.G.S. vol. xliv. p. 11.

[3] I have not a few slides in my collection, representing, among others, the 'Durness,' Wrekin, Hartshill, Lickey, Stiperstones, Cherbourg, and Ardennes quartzsites.

[4] I am indebted to the kindness of Messrs. Peach and Goodchild, and the favour of Sir A. Geikie, for the opportunity of examining a fine specimen of the 'piped' quartzite (Basal Cambrian) from Glendhu, Sutherlandshire, which has become, through great pressure, slabby and schistose. It exhibits a structure with which I was already familiar from other rocks affected by the great thrust faults of the N.W. Highlands, and this is so different from that of the quartz-schists described in this paper that I could distinguish the one from the other at the first glance through the microscope.

[5] I except, of course, the cases where the rock exhibits flexures. Here it may be added that since the first notes of this paper were written I have had the opportunity of seeing the quartz-rocks near Clifden (Connemara)—a prolongation westward of the Twelve Pins. These in the field reminded me frequently of the Alpine quartz-schists, and always appeared to differ from the Durness quartzite; they seem to be

Again, though these quartzites, just enumerated, are separated from the quartz-schists by distinctive characteristics, we find occasionally rocks which may be said to occupy an intermediate position. Of these I possess only a few examples. Some of the Huronian quartzites, which show no signs of pressure, are now quartz-mica rocks, in which, as I have said,[1] we cannot determine what portion of either mineral is allothigenous, and are led to believe that their present forms were assumed *in situ.* I have found the same structure in a pebble from the basal Cambrian conglomerate at St. David's,[2] and may add that small fragments of quartz-schist are often not uncommon among the oldest coarse grits and conglomerates.

But on grits and shales which have been exposed to the action of important earth movements—such as those which come from the Alps themselves—pressure has produced but moderate effects. Certain of the more minute constituents have undergone micro-mineralogical change; but, generally, of the larger constituents, though certain of the more unstable have been altered, most of them are little affected; even fragments of organisms can still be recognized. In the crystalline masses, zones doubtless occur, here and there, where the effects of crushing are very conspicuous; where, for instance, granitic rocks have been converted into fissile fine-grained mica-schists; rocks also there are (such as some of the pyroxenic group), the constituents of which seem exceptionally unstable under pressure, but many large masses are comparatively little affected. On what grounds, then, when the sedimentary rocks have emerged from the pressure with so little loss of personal identity, are we justified in assuming that the crystalline masses have been completely reconstituted, and that the cases just mentioned, instead of indicating the extreme effects of pressure, represent really its partial effects, that is to say, where crushing has been followed only by partial reconstitution. For any such assertion I cannot find the slightest grounds in the Alps.

So the specimens of quartz-schist discussed above (1) give no proof that their structure was caused by pressure; (2) show that if they have been crushed, great molecular changes have since occurred; (3) afford indirect proof that their structure is pre-Tertiary; (4) are not like Palæozoic rocks which have been crushed. In short, pressure is a most important agent of change, but it is far from being the only one. Dynamometamorphism is a fine-sounding term, but "comfortable words" are more suited for old women than for scientific men.

---

associated with crystalline schists. Also the quartz-schists in the district near Braemar; some of which occur near to calc-mica-schists, very like those of the Alps, others pass into mica-schists or a kind of gneiss. In microscopic structure both rocks agree in the main with these Alpine quartz-schists. The gneissoid bands seem likely to confirm the idea expressed above that one kind of gneiss may result from the alteration of a quartz-felspar grit, but I must verify some points before I can venture to say more.

[1] Q.J.G.S. vol. xliv. p. 32.

[2] Geol. Mag. Dec. III. Vol. VI. (1889), pp. 315–318.

IV.—On Post-Eocene Surface-Changes in the London Basin.[1]

By A. Irving, B.A., D.Sc. (Lond.), F.G.S.

The Quarterly Journal of the Geological Society, for 1892,[2] contains a paper by Mr. H. W. Monckton, F.G.S., embodying a useful and valuable collection of observations tending to throw additional light upon the history of the surface-changes, which have taken place in the higher parts of the London Basin in later Tertiary and Quaternary times. The theoretical views put forward in that paper have not, however, altogether the novelty which the author seems to claim for them. He is wrong in coupling my name with that of Prof. Rupert Jones as an advocate of a partial *marine* origin of the gravels, and so claiming novelty for the theory (p. 45) "that all the gravels in the area dealt with were formed after it had for the last time risen above the sea." A few quotations will put this in a clear light.

(*a*) In 1883,[3] I spoke of the plateau-gravels as probably "accumulations produced by powerful river-currents converging possibly to a common estuary" (p. 23), and as having been deposited at a time when "the drainage-system of the area was quite different from that which is seen at the present day" (p. 26). The intermediate pages are mainly occupied with a discussion of the conditions under which I conceived then that their deposition had taken place. More recent observations have but led to the confirmation of that view, and to the dating back of the plateau-gravels to an earlier Tertiary stage than I then ventured to assign them to. I deferred then to the opinion of Prof. Rupert Jones, that the sea had had a share in the deposition of the secondary or terrace-gravels; but more recent and more extended observation compelled me to abandon the idea of marine action, even for them.

(*b*) In 1890,[4] I spoke of the fluviatile transport of the materials from the Wealden uplands to the south, and of the "transport of the angular flint-material by rivers from the Weald across the northward sloping plateau of Eocene land" (p. 558); of the materials being "carried northwards and deposited in lines of river-drainage or spread out on flats, where the declivity of the plateau diminished," comparing this (in a footnote) with my own observations in former years of the "gravelly detritus laid down by Alpine rivers, as they debouch upon the Plain of Bavaria" (p. 559); of their stratification, in most cases as clear as those of the low-level gravels of the present Thames Valley, as "a fact, which seems to point clearly to their river-origin" (p. 560); and of their remaining as "indexes of ancient Pliocene lines of drainage, having preserved the present hills from degradation, while the originally higher ground has been scored with the present valley-system" (p. 561). Other passages of similar import might be quoted from the same paper, and from a paper (supplementary thereto) which appeared in the GEOLOGICAL MAGAZINE [1] for September, 1890. In this last paper the hypothesis of a terrestrial and fluviatile origin is extended even to the high-level inland gravels of the "Mundesley and Westleton" series of Prof. Prestwich.

---

[1] This paper was written some months ago, but has unfortunately been delayed in publication from want of space.—Edit. Geol. Mag.

[2] Q.J.G.S. vol. xlviii. pp. 29–45.

[3] See Proc. Geol. Assoc. vol. viii.

[4] Q.J.G.S. vol. xlvi.

(*c*) In 1891,[2] I put forward the same view even more explicitly in the published summary of a lecture delivered at Windsor on "The Geological History of the Thames Valley." There it is pointed out how the maximum elevation of the Wealden axis in Pliocene time, and the correlative "tilting to the north of the Eocene strata of the Tamisian area," probably furnished all the conditions required for the accumulations of the plateau-gravels, and initiated the present Valley of the Thames itself; and a comparison is drawn between this supposed Pliocene set of conditions and those which can be observed *at the present day*, where the Eastern Alpine rivers spread their sheets of detritus over the Tertiary terrain of Bavaria and Würtemberg, owing to the northerly tilting given to it in the last great stage of Alpine elevation. It was from observations of these in my travels of former years, that the terrestrial origin of our plateau-gravels in Berks and Surrey first clearly suggested itself to me.

In this *northerly tilting of the London Tertiaries* is to be found the explanation of what must otherwise appear an anomaly, in the fact that in my 1890 paper I have been able to recognise gravels of the plateau-series down to levels as low as 300′ and even 200′ above O.D. (Bearwood and Farley Hill), while further south I have not been able to bring gravels at a rather higher altitude (with the present geotectonic structure of the country) into the category of the plateau-gravels, as for instance those on Hartford Bridge Flats. To draw the line between the original plateau-gravels and the secondary gravels of the district, which are either wholly or in part derived from the widely-scattered material of the ancient plateau, is no easy matter, for the two seem to merge into one another. Relative altitudes will not settle the matter, for a gravel, which is nothing more than a mass of material reconstructed out of an ancient gravel of the true plateau-series, may be actually at a higher level than one of that series farther north, owing to the general lowering of the gradient of the northward sloping plateau, from the progressive rate of denudation as you ascend from lower to higher altitudes. After some thought on the matter, and trying first one then another test, by which to differentiate the plateau-gravels from the secondary or terrace-gravels (in which category I have included not only the "glacial gravels" but all the "patches of unstratified and angular gravel found on the higher slopes and minor bluffs of the present valleys, mere 'run-of-the-hill' of the later denudation of the country"), I was unable to find any other basis of classification than that which combines both *structure and composition*. And if under the term "glacial gravels" we include (as I have done all along) those gravelly deposits whose actual structure seems to record the operation of ice as the chief agency, to which the observed structural phenomena are due, we must, as a matter of fact, include in the glacial category many deposits, which might perhaps be excluded therefrom, if we used the term "Glacial" (always mind with a "G") in the narrower and professional sense of the cartographer, which seems to include only those deposits which contain materials foreign to the area in question, such, for example, as the quartzite pebbles derived from the Trias of the Midlands. It is, I imagine, in this narrow and technical sense of the term "Glacial," that the author of the paper referred to at the beginning of this article is inclined to dispute the admission into the glacial series of the contorted gravels and clays at Ninemile Ride, Berks, of which photographs have been taken for the British Association, two of which have been published (one in "Proc. Geol. Assoc," the other in "Science Gossip"), which, moreover, carried the strongest evidence of glacial action, not only to my mind, but to that also of Prof. Spencer, the State Geologist of Georgia (a well-known writer on glaciation), when I took him to the sections in 1890.

---

[1] "Note on the Elevation of the Weald," GEOL. MAG. Dec. III. Vol. VII. p. 403, *et seq.*

[2] See Science Gossip for May and June, 1891.

Similar contortions and puckering of the well-banded clay (No. 5 of the College well-section) are exposed to view in the deep trench by the birch-avenue leading from the Station to the College, which was dug two winters ago. Considerable masses of gravel (chiefly the wreckage of the pebble-bed) are here also driven down into the clay.

I would remind the reader, that, when it comes to the consideration of a case in which glacial action is involved, the value of individual judgments is to a great extent determined by the knowledge on the part of those who form such judgments, (1) of the actual physical laws concerned in the question under consideration, (2) of the phenomena usually known as "glacial" from personal observation of known glaciated regions, such as those of the Alps and other mountain districts. Were it not that I believe him to have been caught in the technical fallacy indicated above, in his forced and artificially-restricted use of the term "glacial" on pp. 40–41 of his paper, I should consider Mr. Monckton's idea too preposterous to admit of serious discussion.

But the same writer has a way of criticising such caricatures of the ideas or theories or views of another writer, as are creatures of his own imagination. So, without really understanding the theory of the late Prof. Carvill Lewis, of Philadelphia, as to the glaciation of the Mercian and East-Anglian regions, and the relation of that to the glaciation of the Thames Valley, he falls into the mistake of supposing that it requires us to "argue for the presence of the sea in this part of the Thames Valley in Glacial times"; while in reality I have but applied the term "Thames Straits" (as writers before me have spoken of the "Severn Straits") to the broad expanse of water, down which probably ice-floes from the Mercian region floated, through the *higher* part of the Goring-Pangbourne Gorge, which has undoubtedly been much deepened and widened both during and since the Glacial Epoch. I put the matter very briefly, but plainly, in my Windsor lecture, to which reference has been already made.

Again, on pages 44 and 45 of the paper, with which I am now dealing, this ghost of the sea having "flowed in the Thames Valley since these [Glacial] Gravels [of the north side of the valley] were deposited," is exorcised, in order, as it seems, to enable the writer, who uses the spell, to "reject the theory, which assigns the contortions observed in clay-beds near Wokingham, to bergs or floes of ice, which floated in waters, that filled that valley up to 240′ above O.D." The simple reply is, that those, who, like myself, have adopted such a view, are responsible for what we have said, and not for any extraneous ideas, which another writer's imagination may have read into it. As a matter of fact, and as Mr. Monckton's own testimony (*loc. cit.*) goes to show, we do find just what we should expect in such a submerged shallow valley: we find on the northern slopes glacial detritus; and we find on the southern slopes materials derived immediately from the plateau-gravels and from the strata of the Bagshot terrain of the higher country, to the south, as the outcrops of these receded southwards with the sub-aërial erosion of the district. Both sets of material would be more or less mingled together along a roughly-median zone of such a submerged valley, just as one may often see, in an isoclinal longitudinal valley of a great mountain-chain (such as the Alps) detritus from the crystalline rocks on one flank of the valley mingled together in the most indiscriminate fashion with detritus from the clastic rocks on the other flank, only needing such a widening of the valley by erosive agencies as would admit of such fluviatile action coming into play, as has evidently given us the stratified low-level gravels of the present Thames Valley, which were long ago commented on by one of the most sagacious of British geologists, the late Prof. John Phillips, F.R.S.[1]

One might easily cite the low-level *stratified* drifts of the Severn Valley, and of many another ancient river-valley, as showing this commingling of local materials with glacial *remanié*, were it not that to deal in this way, with what is but a commonplace of physical geology, would only serve to weary the reader. And as the low-level gravels are stratified, so also is it quite an ordinary thing for glacial materials themselves to have been partially stratified; and that without requiring any long "inter-glacial" periods for the supply of the floods necessary to do the work; since the increased fluviatile action arising from the melting of the snow and ice, as the climate gradually underwent amelioration, would be sufficiently potent as an agent for the work to be done. I will only point out here that in the discussion of my paper on the plateau-gravels (*supra cit.*) in the year 1890, it was admitted, that "such contortions as described were generally accepted as evidence of snow or ice," and that by the very person who, in December, 1891, rejects such an explanation of the case then under consideration, yet without bringing forward anything by way of an argument in support of such a change of view, beyond such as is based upon a misunderstanding of the theory under dispute.

---

[1] See his "Geology of Oxford and the Valley of the Thames."

There remains to be considered some rather puzzling cases of gravels at rather high altitudes, to which I have hesitated to assign a place among the true plateau-gravels. A reference to my 1890 paper[1] will show that I have omitted the gravels of Hartford Bridge Flats from that category. I rejected them, because, notwithstanding their altitude and even their composition (the same as that of the plateau-gravels), I have never been able to see one, among a dozen or more gravel pit sections on that plateau, which answered to the structural test of *stratification.* Many of them are simply pockets of gravel in the eroded hollows of the Upper Bagshot Sands, as above Cricket Hill, and in every case, where I have seen them exposed, they have given me the impression that, as reconstructed material of an older plateau-gravel, they have been degraded into mere *talus*, or have been lowered by "soil-cap" movement due to the removal of sand from beneath them by the action of "high-level" springs. In many cases erosion of this nature has in course of time been sufficiently concentrated locally for small landslips of inversion to occur; and this is probably the explanation of the curious contorted masses of loamy ferruginous sand, which are so often met with in the gravels, and very often occur near the present surface of the ground at rather high altitudes.[2] I have not much doubt that some such explanation applies to the few exceptional cases of contortion and of the absence of stratification in gravels of the plateau, several of which are cited by Mr. Monckton in his paper. These things being considered, I cannot admit that I have "made too much of the question of stratification and contortion" (p. 35).

It seems to be too little realized often by writers on the superficial geology of this part of England, how great the time interval is, since the plateau-gravels were laid down; and unmindfulness of this seems to make them slow to recognise the great extent and variety of the surface-changes, which must have been brought about by the action of ordinary "meteoric" agencies. Many of these have been long since wholly or partly obliterated; and a very great deal of this kind of erasure of surface-phenomena is no doubt to be referred to the Glacial Period, when the action of certain agencies of change was intensified. Erosion of sands beneath the gravels by high-level springs, and consequent "soil-cap" movement has been already referred to; and a little thought will suffice to show how, in the earlier stages of the sculpture of the present country, small ravines would be developed out of what were at first mere rain-water gullies. As surface-erosion continued, co-operating with the action of springs, numerous small landslips must have occurred, and this would scarcely have happened without the surface-drainage of some of the wider upland valleys being in places impeded, the surface-water being ponded back to form pools and lakes, which, as they got silted up, would form morasses or peat-bogs, some of which actually remain to the present day,[1] and illustrate the operation of the same processes of nature as do many peaty floors of modern valleys in the Alps and elsewhere, where valley-lakes have been silted up.

---

[1] Q.J.G.S. (*loc. cit.*) p. 560.

[2] Such contortions in the gravels themselves do not furnish the evidence of glacial action which contortions in the *underlying laminated argillaceous Eocene beds* do furnish.

Among the mineralogical changes which would be brought about under such and similar conditions, would be the formation of limonitic iron-ore and limonitic concretions of sand,[2] in which (as is easy to see) occasional shells of a land- or freshwater-habitat might have been included. One is justified, therefore, in hesitating to accept the occurrence of such limonitic masses in some of the secondary gravels (standing alone) as a part of the wreckage of beds of the Bagshot formation.[3] Again, a little consideration will show that even glauconitic green sand may have been formed locally, under sub-aërial conditions, where the action of decomposing organic matter played a part (as it must have frequently done) in aiding mineral change. The occurrence, therefore, of glauconitic matter in superficial deposits is no more a proof that Middle Bagshot Beds once extended over the particular locality where it is now met with, than the occurrence of limonite is proof of the former existence in other places of the Upper Bagshot Sands. In each case we have no more than a presumptive probability. In some cases we know positively that such glauconitic material *cannot* have been derived from the Middle Bagshot, because those very beds are known to be a considerable distance beneath the locality where the glauconite is met with. Thus, in the cutting at North Court on Finchampstead Ridges, which is demonstrably in Upper Bagshot Sands, grains of glauconite occur sporadically but conspicuously in the massive sand-beds there exposed; and in places this material is collected in holes and pipes, which simulate root-tubes so remarkably, as to make it almost impossible to doubt that the glauconite was formed *in situ*, through the agency of the organic matter furnished by the decay of the roots, which once occupied the tubes now filled with glauconitic sand. Precisely the same phenomena are met with at Bill Hill, Bracknell, as I have pointed out in the unpublished portion of the MS. (now at the Geological Society's Rooms) of the paper read before that Society on Nov. 12th, 1890. A duplicate series of specimens illustrating this was exhibited at the time. The details which I then gave, and which anyone can verify, show that the beds exposed at these two places have such a lithological similarity (in fact almost an identity), that, if we took lithological characters alone as our guide, we should without any hesitation refer the two series of beds to one and the same horizon. While deferring fuller treatment of this for the present, it may be suggested that a due recognition of the probability that (in the vast period of time that surface-changes have been going on in the higher parts of the London Basin) such materials may have been formed locally, and altogether irrespectively of the particular character of the subjacent terrain, must make us cautious in attaching very much stratigraphical significance to such observed facts. When we meet with glauconitic green sand in a gravel not far from, and resting on beds at a lower horizon than, the outcrop of the "green-earth series" of the Bracklesham Beds (so-called), there is no difficulty in considering it as derived from them; but obviously this is *not* the case, when "green sand" occurs in gravels, which overlie Upper Bagshot Sands, as in the instance recorded by Mr. Monckton on page 43 of his recent paper "On the Gravels South of the Thames."

---

[1] Such as that at Mirk Bottom (see 6-in. Ord. Map), where we have made extensive excavations lately.

[2] See my paper "On Organic Matter as a Geological Agent"; Proc. Geol. Assoc. vol. xii. pp. 227 *et seq*. 1892.

[3] See the cases mentioned in the paper (pp. 43, 44), to which reference has been frequently made in this paper.

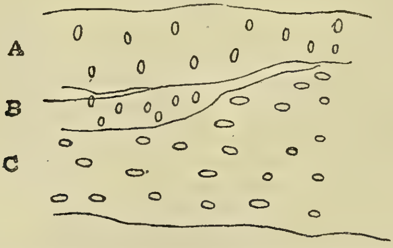
Among the many interesting observations recorded in the same paper, those described on page 43 are of special interest, as illustrating some of the processes of surface-change, accompanied with reconstruction of the materials furnished by the Eocene beds and the high-level gravels during later geologic times. It is true that such "accumulations of sand" in the gravels as are there described may by a casual observer be "easily mistaken for the Bagshot Beds themselves." I well recollect the case near Walton Station. Mr. Hudleston pointed it out to me on my first visit to the place, when the cutting was being widened; and though no gravel was seen at that time below it, as it was later on, when the excavations were carried further, I gave it as my opinion that the mass was only sand included in the gravels; and I felt justified in doing so, not merely from the incoherency of the sand and the relation which its rude stratification bore to the later contour of the adjacent country, but also on the ground that I had a short time before observed the same sort of thing at Ascot. In an old note-book I find the following note, dated 1885:—

S.W. Railway-cutting east of the Race-course Station. "A thin bed of pebbles with a few angular flints comes on east of the bridge. For some yards this is overlain by a stratified brick-earth. Traced to the east, it expands into an ordinary Quaternary drift-gravel filling the eroded hollows of the clean sand beneath. East of the second bridge is a sand-pit in the clean white sand of the Lower Bagshot. This passes up into a curious contorted mass of fragments of a laminated clay mixed with white sand. This in turn passes under the gravel." With a more limited section the loamy bed here noted might have been easily mistaken for a genuine Eocene sand-bed. The fragments of clay are probably *remanié* from the basement-clays of the Middle Group, which occurred at a somewhat higher level.

In the case of the "somewhat similar deposit in the Brick and Tile Company's brickyard north of Bracknell," it is not easy to see how the section there exposed could have been easily mistaken for a Bagshot Bed, as I saw it in 1887. I find the following note of it, which I made on the spot:—"Top of hill, fine section in sand and gravel, irregularly bedded with occasional puckers; no trace of oblique lamination seen, strong dip to the north; beds here and there of pebbles and discoloured angular flints, which are strewn through every portion of the sand, thin clay partings (occasionally an inch thick) with intenser colour in the sands just above them." These sandy portions of the gravel passed southwards into a more gravelly mass, with little or no sand; and on a second visit to the place I found that a deep cutting had been made from the face of the pit down into the London Clay. Here the angular gravel was seen in a fresh open daylight section, running beneath the more sandy portions of the mass, and lying upon an eroded surface of London Clay, well down in which was a layer of flint-pebbles dipping about south-east at an angle of 5°. It is quite easy to see how the *quondam* higher Bagshot terrain immediately to the south had, in the denudation of the country, furnished the materials: (1) the flinty material from its surface to form the more gravelly part of the deposit; (2) the sandy material, which (with some admixture of flinty stuff) had been washed down over it, the whole mass being nothing more than a talus-deposit against the flank of a hill, which has since disappeared. But the interest of the section does not end here, for it afforded evidence of glaciation and of the pre-Glacial age of this secondary gravel, as may be seen from the following note made on the spot:—"On the worn and eroded surface of the above lies a glacial deposit (in fact a 'Boulder-clay') with a maximum thickness of 5 feet, full of pebbles and angular flint fragments, generally standing on end." In my paper of 1890 on the plateau-gravels[1] I have referred to this as "an unstratified Boulder-clay, with pebbles standing erect in it, lying upon an older angular and sandy gravel, which lies upon an eroded surface of the London Clay."

A similar deposit occurs at Kintbury, near Newbury, for which I am indebted to Mr. F. J. Bennett of the Geological Survey, who about the same date made the following entry in my note-book:—

Fig. 1.



A. Pebbles in sandy matrix, clayey here and there, pebbles mostly vertical.
B. Pebbles in grey stiff pipe-clay, pebbles also vertical.
C. Pebbles in soft Bagshot sand, mostly horizontal.

In the case at Kintbury, as in that described above north of Bracknell, it is easy to understand how ordinary currents would lay down pebbles and flint fragments horizontally, but not so with the vertical pebbles. A little thought, with the application of the most rudimentary mechanical principles, will however reveal the fact that the same mechanical law applies in both cases. A pebble free to rotate in water upon any axis will assume a permanent direction of its longer axis only in the position of least resistance to the surrounding medium, and this position is attained, when the smallest possible section is opposed to the water. This is equally true, whether the water is flowing past a pebble lying on its bed, or the pebble is itself moving in obedience to the law of gravitation through still water. In the former case the ultimate position of the pebble is *horizontal*, in the latter it is *vertical*; and if it falls into soft mud or silt it will retain this vertical position after coming to rest at the bottom. The conditions, which most readily meet the requirements of the problem before us, are those of a detritus-laden mass of ice floating and gradually melting away in the water of a lake, or the "backwater" of a broad shallow river. In fact, in order to explain the actual phenomena in the one case and in the other, we are thrown back upon such conditions as are implied in the "Thames Straits" hypothesis.

---

[1] Q.J.G.S. vol. xlvi. p. 562.

But the facts just described do not stand alone in the immediate locality north of Bracknell, as the following note (made also in 1887) of a new section at Messrs. Lawrence's brickyard close by plainly shows:—

"Upper beds seen in the new pit (about five yards square), a somewhat remarkable deposit containing very pure pipe-clay seams (in some cases three or four inches thick), running very irregularly through a coarse ferruginous sand, not laminated or distinctly stratified. In the sands (generally above the pipe-clay seams) occur layers of bog-iron-ore, and portions of the sand are cemented into concretionary masses by carbonate of iron. Height of section nine feet." The floor of the open pit was formed by the undisturbed pebble-bed.

This was a new exposure of bed (*a*) of the published section (F)[1] of my 1887 paper, "On the Physical History of the Bagshot Beds of the London Basin," and the new section strongly impressed me with the lacustrine character of the bed. I never saw anything like it in undoubted Bagshot Beds. The pipe-clay occurred here in a way in which it is occasionally met with in the gravels (as at Walton), and was not interstratified (as in the true Eocene beds) with regularly bedded sands. I still hold to the view that it records one of the many surface-changes leading to the reconstruction of Bagshot materials, supplemented by other material, which would vary with the conditions locally prevailing at the time. It is more likely than not that the pipe-clay of this and similar deposits, for which I have suggested a later date than the Eocene, may be the insoluble residue of ice-borne chalky detritus[2] from the Kennet

---

[1] Q.J.G.S., vol. xliii. p. 386.

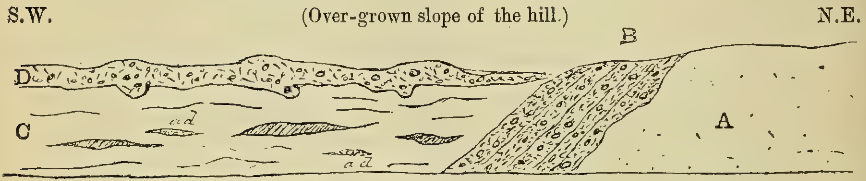
[2] See my paper on "Physical Studies of our Ancient Estuary," Geol. Mag. for 1891, Dec. III. Vol. VIII. p. 357.

Valley and the Pangbourne Gorge, the ice-rafts which conveyed it to the spot having floated in succession into one of those backwaters of the "Thames Straits," which were caused by some details of surface-contour long since swept away.

This paper has already grown to considerable proportions. I will therefore describe but one more instance of surface-change. The deposits referred to were laid open a short time ago in widening the road-cutting below the church at York Town, Surrey, as indicated in the accompanying diagram:—

Fig. 2.

Road-section at York Town, Surrey.



Line of road.

A. Ferruginous Upper Bagshot Sands, part of the terrain of the district.

B. Reconstructed materials of the Plateau-gravels, on an ancient hill-slope (talus).

C. Fine irregularly-bedded quartz-sand with occasional discontinuous zones marked by oblique lamination, and here and there some small inclusions (*a*, *d*) of fine angular flint detritus; the whole extending many yards along the road-side.

D. Quaternary gravel of the ordinary character filling eroded hollows on the top of bed C.

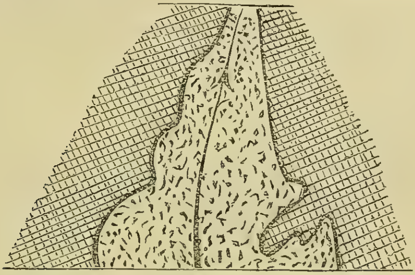
The massive bed, A, calls for no remark. The talus, B (with just that crude stratification which distinguishes a true stream-wrought "talus" from a "scree"), seems to record a very early stage of the sculpturing of the present upland valley-system. But it is to the bed C that the chief interest attaches. I do not hesitate to call it a truly *lacustrine* deposit, and perhaps its position with reference to the overlying secondary gravel and its altitude would justify one in assigning to it a date as old at least as the Glacial Period. Anyhow there could be no possible mistake as to its being a good deal younger than the Upper Bagshot Sands (A) at the northern end of the section. Yet, were it not for the small inclusion or two of fine flinty detritus (*a*, *d*), which might be absent altogether if the excavation were carried a few feet further into the hill, I have little doubt that (standing by itself) it would, on lithological grounds alone, have been claimed by certain writers on Bagshot stratigraphy as a "characteristic section of Lower Bagshot Sands." Cases of this sort are seen to discount largely the value of the purely lithological method, on which so much reliance is placed in certain quarters.

V.—Note on a Coast-Section at the Lizard.

By C. S. Du Riche Preller, M.A., Ph.D., Assoc.M.I.C.E., F.C.S., F.G.S.

AT the meeting of the Geological Society on February 8th, Mr. Teall exhibited, as one of the illustrations of his paper "On some Coast-Sections at the Lizard," an eminently characteristic and instructive diagram of serpentine and granite in juxtaposition; and the interesting question whether the granite was intrusive in the serpentine or *vice versa*, was ventilated and discussed, but by no means decided.

From the accompanying sketch of the salient features of that section, it will be seen that the granitic mass, having the shape of an irregular inverted pear in longitudinal section, broad at the base, and gradually narrowing towards the upper end, is flanked on both sides by the serpentine which, at one point, on the right side, projects into the granite in the shape of a tongue. In the opinion of some, this last-named phenonenon seemed to lend weight to the conjecture that the serpentine was intrusive in the granite, in which case it would, of course, be younger than the latter. But, in my opinion, that very phenomenon affords conclusive proof of the contrary being the case; for the tongue-shaped projection is only an indication that, at this particular point, the serpentine offered to the intrusive granite greater resistance than at other points of the section, that greater resistance being due to the more advanced state of solidification of the serpentine at that point when the granite erupted. This view appears further strengthened by the fact of the axis of the tongue pointing obliquely downward, in the teeth as it were, of the upward flow of the intrusive granite, which forced back the more yielding, viz. more or less plastic part of the serpentine, and left the already solidified nucleus in the form shown in the diagram. Moreover, to the sharp inward curve of the granitic contact line produced by the serpentine tongue on the right, corresponds an outward curve on the left or opposite side, and the section thus exhibits the ordinary physical conditions of flow, the axis of the granitic complex being, on the whole, a flat curve, determined by the lateral resistance which that mass encountered in forcing its way upwards. The evidently more or less plastic condition of the serpentine at the time of the granitic intrusion also tends to show that the eruption

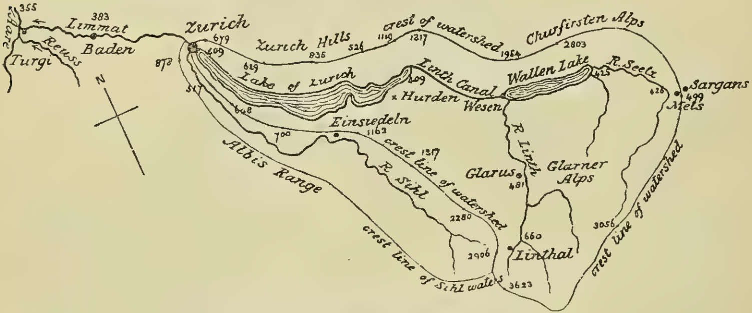


of both (granting the serpentine to be of igneous origin) took place in the course of the same geological epoch, although this has not yet been fixed. At all events, the grounds above stated undoubtedly warrant the conclusion that, in the characteristic section of the coast east of the Lion Rock, Kynance, the granite was intrusive in, and is, therefore, somewhat younger than the serpentine; and this may, not unreasonably, lead to the conjecture that both are considerably younger than the pre-Cambrian hornblende-schist of the district.

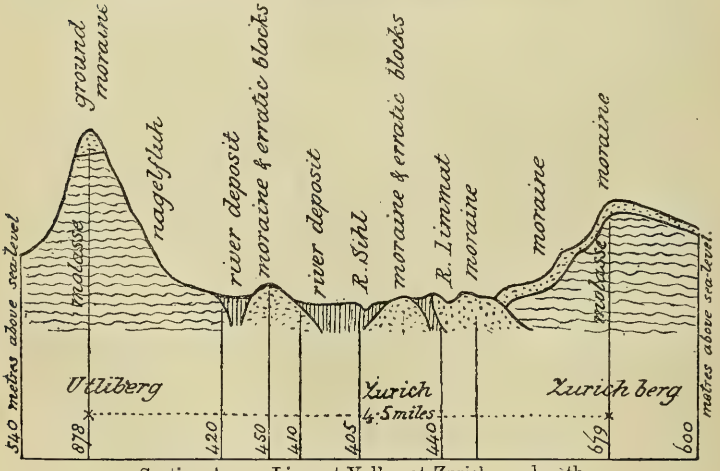
VI.—NOTE ON THE LAKES OF ZURICH AND WALLEN.

By C. S. DU RICHE PRELLER, M.A., Ph.D., Assoc.M.I.C.E., F.C.S., F.G.S.

IN the course of the summer 1892, I had occasion to visit and examine the drainage area of the Lake of Zurich, including that of the Wallensee; and this gave rise to some interesting observations relating more especially to the origin of those lakes, to the high degree of purification of their waters by chemical and mechanical agency, and to some noteworthy effects of certain geological changes in their watersheds.



Drainage Area of Lake Zurich.
The figures indicate the altitudes in metres above the sea-level.



Section Across Limmat Valley at Zurich, $\frac{1}{100000}$th.

1. The drainage area of the lake of Zurich comprises about 420 square miles, the principal tributaries being the rivers Seetz and Linth. Both these rivers rise in the Glarner Alps and discharge into the Wallen lake which, in its turn, drains into the Lake of Zurich by means of the famous Escher-Linth canal. In addition to the discharge of the Wallen lake, which is essentially Alpine in character, the Lake of Zurich receives the waters of the sub-Alpine hills; and the lower part of the whole drainage area is composed of Oligocene molasse and Miocene nagelfluh, the upper part of the series characteristic of the Glarner Alps, viz. Eocene "flysch" (sandstone, limestone and marl), Cretaceous "seewen" limestone, Jurassic (malm and dogger) limestone, and Triassic Buntsandstein, the building up of the successive Jurassic and Cretaceous series being especially conspicuous in the Glarnisch, the central member of this group of the Alps. There can be no doubt that, at one time, the upper (Wallen) and lower (Zurich) lakes formed one lake, the subsequent division being due to the material brought down from the Alps and deposited by the river Linth, thus forming a post-Tertiary intermediate tract of marshy and now reclaimed land, just as the detritus carried down from the Iungfrau group by the River Lütschinen gradually separated the lakes of Brienz and Thun, and formed the intermediate tract of land from which Interlaken derives its name. The difference of level between the Wallen-lake and that of Zurich is 46 feet, the level of the former having been gradually raised by the action of the Linth as already explained, until that river, instead of emptying itself into, and more or less submerging, the tract between the two lakes, was canalized in its lower section and made to discharge into the Wallen-lake. A further characteristic point in relation to the Wallen-lake is the evident connection which at one time existed between it and the Rhine valley, until a low saddle of less than one mile in length and only 60 feet in depth was thrown across the defile between the Glarner and the Churfirsten Alps near Mels and Sargans by the detritus carried down by the river Seetz, thus separating the watersheds of the Rhine and Linth or Limmat systems.

The notion which is still accepted by many, that the principal Alpine Lakes owe their origin to glacial erosion, is completely falsified by the two lakes in question. The greatest known depth of the Wallen-lake is 560 feet, that of the Lake of Zurich 460 feet; but at that depth the bottom only consists of soft mud, and the true or solid bottom is at an unknown, probably much greater, depth. This circumstance must lead to the conclusion that the two lakes owe their origin, not to glacial action, but to a deep rent formed by the shrinkage of the earth's crust and the consequent thrusting and subsidences during the great Alpine movements of Tertiary age. The evidence of this cleft or rent is particularly striking in the Wallen-lake. The axis of the fissure, running in the longitudinal direction of the lakes, is parallel to that of the (Jurassic) Churfirsten Alps flanking the Wallen-lake, and of the (molasse) range of hills flanking the Lake of Zurich, the tributary valleys of the drainage areas being more or less at right angles to it. It was this fissure which subsequently facilitated the intrusion and purely abrasive action of the glaciers; and these were, therefore, the secondary, but not the primary agency; or, as Prof. Bonney aptly expresses it, the glaciers must be regarded as the file rather than the chisel of nature.[1]

2. The superficial area of the Wallen-lake and that of Zurich is 9 and 34 square miles; their mean depth is 500 and 230 ft. respectively, and their average contents may therefore be computed at 3500 million and 6000 million tons (or cubic metres) of water respectively. It is evident that the Wallen-lake acts in relation to the Lake of Zurich, as a vast storage and clearing reservoir of the waters descending from the Alps; and its purifying action is rendered all the more effectual by the equable discharge of the Alpine rivers due to their origin in the glaciers. In both lakes, but more especially in the larger Lake of Zurich, the natural purification of water is effected by the precipitation of impure matter, favoured by the slow motion of the water; by extensive oxidation promoted by the large surface of water in contact with the air; by the water being kept in motion by occasional storms, and in the Lake of Zurich, moreover, by navigation; by solar heat, which extracts oxygen from aquatic plants; by an aquatic fauna of great variety, which collects at the outflow of drains and streams and feeds on the impure matter with which they are charged; and lastly, by the innumerable quantities of voracious micro-organisms living at the bottom of the lake. The extremely slow motion of the water through the lake as a purifying agency is evidenced by the fact that, the mean discharge from the lake into the river Limmat at Zurich being eight million tons per day, and its contents being 6000 million tons, it takes 750 days, or more than two years, before the water flowing into the lake at the upper end reaches the point of outflow at the lower or Zurich end. It is owing to this, in conjunction with the other chemical and mechanical agencies enumerated, that the water of the Lake of Zurich contains, on an average, only 170 bacteria (collectively about the size of the head of a small pin) per cubic centimetre, and that of the other Swiss lakes has been found to contain even less, *e.g.* the Lake of Constance 58, that of Lucerne 50, and that of Geneva only 38; whereas the spring water of the Zurich hills, especially after rain, often contains as many as 2000 bacteria per cubic centimetre. Having regard to the comparative size and depth of these several Alpine lakes, it may be legitimately inferred that, generally speaking, the larger their superficial area and the greater their depth, the more effectual is the natural process of purification of the water contained in them.

3. An instructive instance of the deviation of water-courses as the result of geological changes is afforded by the river Sihl, which rises in the Glarner Alps of the Canton of Schwyz, beyond the Convent of Einsiedeln, about thirty miles from Zurich. This river at one time emptied itself direct into the lake of Zurich near the upper end, not far from the island of Ufenau and opposite Rapperswil, where the accumulated detritus brought down by it projects into the

---

[1] The Building of the Alps, Royal Institution, 1884.

lake and forms the tongue of Hurden, about two miles in length and less than half a mile in width. The peculiarly coarse sand and fine gravel which is extensively quarried in this locality and is found at no other point of the lake, affords unmistakable evidence of this being the former outlet of the river. In the course of subsequent dislocations in the upper strata, the old bed was barred, and the river scooped out a new bed through the molasse and nagelfluh of the Albis range of hills, parallel and in close proximity to the lake. The Sihl falls into the Limmat about a mile below the outflow of the latter from the lake, and has an average flow of about one million tons per day, equal to one-eighth of that of the Limmat, although, when in flood, it exceeds at times the mean water volume of the latter. It follows that when the drainage area of the Sihl still formed part of that of the lake of Zurich, the latter must have covered a much larger superficial area than it does now, and that this area had not only a higher level but must have probably extended some twelve miles below Zurich, viz. to the neighbourhood of Baden, where the valley abruptly narrows into a defile of about two miles in length, through which the Limmat rushes to its confluence with the Aare and Reuss at Turgi with a considerable fall.

NOTICES OF MEMOIRS.

I.—The Antarctic Continent.

UNDER the title of "The Chatham Islands: their relation to a former Antarctic Continent," Mr. Henry O. Forbes, F.R.G.S., read a most interesting paper before the Royal Geographical Society, illustrated by maps and figures, in which he gave an admirable account of the Chatham Islands, which lie on the extreme verge of the 180° meridian and 500 miles east of Port Lyttelton, in the south island of New Zealand. Wharekauri, the largest of the group, is 36 miles long, in an east and west direction, and 27 miles broad, from north to south; while Rangiauria, the next biggest, is 9 miles long by 6 miles wide. Since 1840, when they were visited and described by Dr. Dieffenbach, on behalf of the New Zealand Company (see Journ. R. Geogr. Sec. vol. xi. 1841), "now half a century ago, considerable changes have taken place in the outward aspect of the islands. The more or less extensive forests that grew on many parts of the land have to a great extent disappeared to make place for sheep pastures or cultivated fields. The Morioris, or original inhabitants of the Archipelago, whose ranks first thinned by an incursion of Maoris from New Zealand, who for the express purpose of feeding on them had themselves transported thither, have all but vanished, and only a family or two now remain of a race that within the next decade or so will have to be numbered with the Tasmanians and with the wonderful birds that once inhabited with them this isolated spot of land. The Maoris, who since that incursion have possessed, by right of seizure, I suppose, a considerable part of the land, are also fast decreasing in number through disease and drink.

The greater part of the islands, therefore, is owned by European run-holders and stocked with sheep and a few cattle."

After describing the flora of the Islands, and the wealth of Ocean birds which make their residence here, or come to these shores in the breeding-season, Mr. Forbes tells us—

"The whole surface of the islands, especially Wharekauri and Rangiauria, is covered with a bed of peat in places over 40 feet in depth—deeper in the northern arm than in the southern—traversable in safety only by those acquainted with the country; for to the inexperienced eye there seems in most places no difference in the surface which can carry with safety both horse and rider, and that on which the lightest-footed pedestrian could not venture without being engulfed. The surface of some of the larger and wetter depressions in the ground was covered with a brilliant-coloured carpet of luxuriant mosses, emitting an aromatic fragrance, spread out in artless undesigned parterres of rich commingled green, yellow, and purple, and endless shades of these, warning the traveller of the existence of dangerous bogs beneath, and brightening miles of treeless moorland, which, but for these floating gardens, would be uninviting and uninteresting. In many places all over the island this great peat moss is on fire, and has for years been smouldering underground, or burning in the exposed faces of the great pits which have now been burnt out. Dr. Dieffenbach mentions their existence at his visit in 1840, and states that the combustion had begun before 1834, and 'may indeed be traced to a much earlier period, and, in consequence, the soil in the neighbourhood is gradually sinking.' These fires, as far as I could gather, had been burning in one part or another of the island ever since Dieffenbach's visit. Whether the soil has been lit accidentally or on purpose, or has spontaneously taken fire through the decomposition of the peat and lignite, I could not ascertain. A peculiarity in the main island that strikes the visitor very early is the occurrence of many lakes and tarns. These lakes are, for the most part, on the eastern side, at the back of the low hills facing Petre Bay. The largest is 15 miles long, over 40 miles in circumference, and about 10½ miles at its widest part; and, therefore, occupies a large portion of the entire area of the island. Some of these tarns occur even on the highest part of the southern highlands."

Mr. Forbes's main object in visiting Chatham Islands was to discover the remains of a bird, some bones of which had been sent to New Zealand, and which opened up problems of geographical distribution of the highest interest. He writes:—

"Within a few days of my arrival, I had the satisfaction of disentombing from their ancient burial ground in the sand-hills of the Waitangi beach, the complete head and the greater part of the skeleton, certainly all important bones, of the bird to which the head belonged. Associated with them were also those of a tall, extinct coot, and a large raven of an ancient type. I was thus able to confirm my doubtful identification of the bones, that the bird which in ancient days had lived in the Chatham Islands, was no other than a species of Aphanapteryx, a large and remarkable member of the rail family, which was contemporary with the celebrated dodo in the Island of Mauritius. That island had been till then the only place in the world where the Aphanapteryx was known to exist, and where it had with the dodo preserved its fading race down to about two hundred years ago, when both of these groups passed away and perished for ever from among living things. In the Chatham Islands I found the remains of the Aphanapteryx in kitchen middens of the Morioris, showing that in this region of the world also it had survived down to comparatively recent date, just as the moa had in New Zealand. To find bones of this bird was, therefore, the main object of my visit to the Chatham Islands, but I had in view also to search for evidences of the former existence there of the moa, the apteryx and the weka, characteristic birds of the New Zealand fauna, and to indicate the value and importance to natural and to geographical science, of their occurrence in this island, is the chief reason of my paper to-night." . . . .

"Deduced from the study of the distribution of species, it has come to be an accepted law that, 'Whenever we find that a considerable number of the mammals (or what is practically the same thing, of flightless birds) of two countries exhibit distinct marks of relationship, we may be sure that an actual land connection, or at all events an approach to within a very few miles of each other, has at one time existed' (Wallace, 'Island Life,' 2nd ed. p. 74). Now, besides this remarkable Aphanapteryx, I gathered on the Chatham Islands the bones of other birds now extinct there, but identical with species now living in New Zealand, and some of them characteristic of that island, such as the *Kea*, that peculiar parrot which has so changed its diet within recent years that forsaking fruits, it attacks and kills the sheep by eating through their backs into their vital organs; as well as the flightless wood-hen, a species apparently identical with that of South Island (*Ocydromus australis*), a species of owl (*Glaucidium Novæ Zelandiæ*) and the smaller of the two species of New Zealand hawk. In addition to these I obtained a species of swan which once lived (though now extinct) in New Zealand; and the tuatara, a curious and ancient form of lizard absolutely confined to the main group. The occurrence in the Chatham Islands of these species, some of which, like the flightless wood-hen, and the Kea among birds and the tuatura lizard, which could not have crossed the intervening 500 miles of sea with the organs of locomotion they possess, proves that the Chatham Islands must have had at one time a continuous land connection with New Zealand. Its geological structure shows it to be a continental island, for though essentially volcanic, it possesses sedimentary rocks of palæozoic, secondary, and tertiary age, and its flora, which is most closely related to that of its larger neighbours, confirms this opinion as well as the shallowness of the intervening sea where the whalers it is said found soundings.

Confined now to one of the smaller, though once widely spread over the whole of the Chatham Islands, lives a flightless species of rail of the genus (*Cabalus*) kin to the woodhens, but which is quite unknown in New Zealand, but strangely enough appears again in Lord Howe's Island, far to the north-west, in the Tasman Sea. On the other hand, in the Antipodes, the Auckland, the Macquarrie, and the Campbell Islands, far to the south, we have birds such as the New Zealand woodhen, and a parrot belonging to the red-headed group (*Cyanorhamphus*) common both to the mainland and to the Chatham Islands, as well as many plants common to one or more of these southern islands, and to New Zealand or the Chatham Islands, proclaiming that these island specks are but the fragments protruding above the surface of the sea of a continent or continental island now broken up, and all but totally covered.

It seems pretty certain therefore that 'the Bampton shoal west of New Caledonia, and Lord Howe's Island further south,' and perhaps also New Caledonia and Fiji, formed the northern and western limits of this former extensive continental island, which almost certainly also extended east to the Chatham Islands, and most probably south and east to the Macquarrie and the Antipodes Islands which we may name *Antipodea.*

Now turning for a little to another quarter of the globe, to the region of the Mascarene Islands, we find that François Leguat, the French Huguenot emigrant from Europe to South Africa, who lived in several of these islands, and recorded with great exactness all that he suffered and all that he saw in his "Voyage." He specially describes the *solitaire,* a great flightless pigeon, and also a woodhen, or *gelinote,* with a red beak and red borders to its eyes. Remains of this bird have been discovered along with those of the solitaire, and have been determined to belong to a great species of rail, nearly related to the woodhens of New Zealand. From its hostility to red the generic name of *Erythromachus* has been applied to it.

The Island of Mauritius, 95 miles to the south-west, was inhabited by the great dodo (*Didus ineptus*), which was also a gigantic flightless pigeon, living on the ground. It was a very near relative of the solitaire, as was finally proved by an examination of the large collection of its bones received in Europe in 1866, among which there were several of another bird then unknown, and which continued to be so till the year 1868, when Herr von Frauenfeld discovered in the library of the Emperor of Austria the picture of a remarkable bird, a tall crane or woodhen, so closely agreeing with the description of the gelinote given by Leguat as to leave no doubt as to its identity. The bones found mixed with those of the dodo turned out unquestionably to belong to this fine woodhen, which was named *Aphanapteryx.* Both birds, however, were of the closest kin to each other, and must have had a common ancestor; but their nearest relatives elsewhere are the wekas, or woodhens, of New Zealand. At the present day there are no birds in either Rodriguez or Mauritius nearly related to the Ocydromine group of the rails. Professor Newton also and his brother, Sir Edward, consider it 'impossible on any other reasonable supposition than that of a common ancestry to account for the distribution of the animal forms that they present. These authors are compelled to the belief that there was once a time when Rodriguez, Mauritius, Bourbon, Madagascar, and the Seychelles were connected by dry land which we may name Mascarenia, and that that time is sufficiently remote to have permitted the descendants of the original inhabitants of this now submerged continent to become modified into the many representative forms which are now known. . . . That the solitaire of Rodriguez and the dodo of Mauritius, much as they eventually came to differ, sprang from one and the same stock, seems a deduction so obvious that the authors can no more conceive anyone fully acquainted with the facts of the case hesitating about its adoption' ('Voyage of François Leguat,' vol. ii. p. 356—Hakluyt Society, 1891).

On comparing the bones of the *Aphanapteryx* brought from the Chatham Islands with those of the Mauritius bird, I have found them to be so closely related as to be almost inseparable. Indeed, these bones from Wharekauri and Mauritius, over 120° of longitude apart, are more nearly related to each other than the *Erythromachus* of Rodriguez (an island of its own archipelago, only 95 miles distant) is with the *Aphanapteryx* of Mauritius.

The question arises how came they to inhabit such widely separated regions? There is only one deduction: the members of the genus must have reached their respective homes by some continuous land connection between the two places. In order, however, to make as clear as possible the route by which Mr. Forbes believed these descendants of a common ancestor reached habitats so far apart, he discussed the distribution of life in other regions of the hemisphere.

In the southern regions of the great continents, in the southern part of South America, in South Africa, in Australia, and in New Zealand, we have forms, either still living or now extinct, that are so closely related as to indicate that they have sprung from a common ancestor. In New Zealand there occur the remains of the moa, which stood over 10 feet in height, a member of the ancient family of the ostriches. It lived down to comparatively recent times and goes back to about the newer Pliocene or Pleistocene age. We have also here a somewhat aberrant form of the same family, the kiwi, or apteryx, still living. In Australia there existed a now extinct genus of the same family, the *Dromornis*; and two genera alive, the emu and the cassowary—the latter extending into New Guinea and some of the surrounding islands. In Madagascar we find in a fossil state the bones of a large species of the same group, the *Æpyornis*; I have lately examined specimens of its bones recently received in the British Museum, whose similarity to those of the moa is so great that if they had been discovered in New Zealand they would, I believe, undoubtedly have been referred to a species of moa. In Africa we have the aberrant ostrich. While in

South America, where the rheas occur, there has lately been discovered in the Tertiary of Patagonia the remains of great flightless birds belonging to the *Struthionidæ*. This family is, therefore, practically confined to the southern hemisphere with few exceptions. Again, the family of the Trogons is confined almost entirely to regions south of the equator. The penguins (*Spheniscidæ*) form a group still more closely restricted to Southern latitudes. Two ancient forms, *Palæeudyptes*, *Palæospheniscus*, are known in the early Tertiaries of New Zealand and of Patagonia. They now range from South America, South Africa, Australia, and New Zealand, to the Antarctic Islands. To the latter, *i.e.*, the Falkland, the Crozet, and Kerguelen Islands, the family of the *Chionidæ*, a peculiar group of white birds related to the plovers, is also restricted. The great group of the parrots (*Psittacomorphæ*) have, as pointed out by Professor Huxley long ago, related, but very distinct families, in Australasia and in South America; they are feebly represented in India and South Africa, and have only a straggler here and there in North America. They are essentially a southern group.

Turning to another section of the animal kingdom, we find wonderfully developed in Australia, and in New Guinea, and some of the neighbouring islands, the marsupials, or kangaroos and wombats, a group occurring nowhere else except in South America; but the marsupials living now in Australia are not very nearly allied to those in South America. In the Pliocene age, however, there lived in East Australia gigantic forms of the family, the *Diprotodon*, the *Nototherium*, the marsupial lion (*Thylacoleo*), and others; and quite recently remains of the genera *Prothylacinus*, *Amphiproviverra*, closely related to the Tasmanian Devil (*Thylacinus*), and to other *Dasyuridæ* of both Tasmania and Australia, have been discovered in the Eocene of Patagonia.

Another very extraordinary group (the Edentata), the ant-eaters, sloths, and armadillos, now live in the southern parts of South America. In more ancient times the order was represented by still more bizarre forms, such as the *Glyptodon*, the *Mylodon*, and the *Megatherium*. In South Africa are the Aard-varks (*Orycteropidæ*), while in India, and some of the Indian Islands, we find Pangolins, or ant-eaters (*Manidæ*), which are all members of the same order. They are scarcely known in the northern hemisphere, and then only in its warmest regions; but they have been recently found fossil in Upper Miocene beds in Samos by Dr. Forsyth-Major.

The well-known examples of Amphibia, confined to Notogæa, or the Southern Hemisphere, we have *Cystognathidæ*, found in Australia, Tasmania, and South America; and of freshwater fishes, we have the *Haplochitondæ*, or southern salmon, and the southern pikes (*Galaxiidæ*), families both unknown north of the Equator, occurring in New Zealand, Chili, Patagonia, and the Falkland Islands.

If we turn to plants, and takinggroups that are confined, or nearly so, to the Southern Hemisphere we find among the *Saxifrageæ*, that two of its tribes (*Escalloni*, consisting of seventeen genera, and *Cunonieæ*, with eighteen genera), are confined (almost) to New Caledonia, Australia, Tasmania, New Zealand, the Mascarene Islands, South Africa, and South America. Of their thirty-five genera two only cross the equator into the northern hemisphere. Of the *Proteaceæ*, composed of forty-nine genera and nine hundred and fifty species, only twenty-five species cross the Equator, otherwise they are distributed to all the southern continents with Madagascar, Tasmania, New Zealand, and New Caledonia; but they occur in Miocene and Cretaceous strata in Europe.

Mr. Forbes, after discussing the opinions of Wallace, Darwin, and Blanford for and against an extensive land area in the Antarctic Ocean, remarks:—In considering the number of genera, or species of the same groups that have reached the three terminal regions of the land in the southern hemisphere, it seems almost too remarkable to believe that it should have been the same forms in more than one that have alone been able to survive the vicissitudes of retreat against 'the pressure of more specialised types' through such different lands from the north to the south, without leaving often a single representative north of the equator and yet should have succeeded in resisting being driven right into the southern sea. It is besides a biological axiom that two identical species have never independently arisen in distant localities.

The Author of the paper then proceeded to adduce the evidence brought forward by Huxley in regard to the distribution of the Peristeropodes (of the Gallinaceæ), and of the Parrots, and that by Prof. W. K. Parker, our most penetrating embryologist, and the foremost of the interpreters of those passing structures in the embryo, which appearing but for an hour, and vanishing as if they had never been, yet so surely proclaim its pedigree and inheritances, in his paper on the Ægithognathous birds, in which are described the affinities between (among other groups) the Australian *Gymnorhinidæ* and the South American *Dendrocolaptidæ*—groups unknown north of the equator.

This evidence, he considers, of the weightiest kind in support of the hypothesis that there existed a large land extension round the South Pole joining South America and Australia, and approaching to, or intermittently only connected with, South Africa, possessing a genial climate, on which the progenitors of these groups common to Australia and South America, which have now lost their nearest relations, could multiply, became modified, and eventually migrated northward on the return of colder epochs, or on account of the subsidence of the land.

Before considering how far the presence of such an austral continent would explain the distribution of life, Mr. Forbes referred to the climate of the southern hemisphere during the later geological periods. He referred to the evidences of glaciation in South Africa, in South America, in Australia, and in New Zealand, dating from a comparatively recent epoch. Mr. Forbes accepted Sir Robert Ball's emphatic declaration: 'It is an essential doctrine of the astronomical theory of the ice age that the respective glaciations of the two hemispheres were *not* simultaneous,' but were alternate. And 'if it could be shown that the ice ages in the two hemispheres were concurrent, the astronomical doctrine would have to be forthwith abandoned.' This glacial age, of which evidences have been found in the southern continents, must, if Sir Robert Ball's assertion be correct, have taken place during a genial period in the northern hemisphere. Now during the Miocene age there was such a warm period (doubtless due to a period of high eccentricity) when a luxuriant flora flourished in the Arctic regions to within 8½° of the Pole.

"The outlines of this Antarctic continent it is of course impossible to trace with anything approaching to accuracy till we are in possession of a larger number of soundings. But it is not unlikely that the great meridional masses of land—or world ridges—which are probably of primeval antiquity extended to meet prolongations running northward from the Antarctic continent. There is some evidence that the direct union of the Antarctic continent with South Africa was not for so prolonged a period as with the others. The presence of the *Aphanapteryx* and other ocydromine birds both in Mascarenia and in Antipodea supports other evidence pointing to an extension of that area south by Marion and Kerguelen Islands, and of New Zealand south, by way of the Macquarrie, Auckland, and Antipodes Islands. It is interesting to observe that the great Pacific trough to the east of the longitude of New Zealand extends far south into the Antarctic land."

Mr. Forbes next discussed the evidence derivable from the flora of the islands in the Antarctic Ocean, and argued that it also indicated a more extensive land in those seas.

Mr. Forbes's conception of the form of this Antarctic continent is thus described :—"The Geological evidence shows that New Zealand was separated from Australia during all the Tertiary period, and that East and West Australia existed as two islands during a portion of the Cretaceous and Tertiary ages ; so that in the early Tertiary period, at least, there were three separate islands, West Australia, East Australia, and New Zealand, the two latter with southern extensions. The New Zealand eastern shore-line extended not improbably from the Chatham Islands, by Young Island, to Victoria Land, where the Pacific trough runs far to the south, and northwest from the Chatham Islands, by Norfolk Island, near to—and, perhaps, including—New Caledonia and Fiji ; southwards, by Lord Howe's Island to the west of Stewart and Macquarrie Islands, where turning south and westward, it united with the eastern shore of East Australia, prolonged south to the Antarctic Land ; its northern extension probably connecting the Great Papuasian Land (New Guinea, the Solomons, New Britain, and New Ireland) across Torres Straits—West Australia at this period, and for a long time previously and after, remaining a large and isolated island. The western shore of East Australia then ran southward and westward to Wilkes Land, where, about the longitude of 90° E., the trough of the Indian Ocean extends south towards the Pole, once more trending northward by

Kemp Island, and Kerguelen Land to join the Ethiopian region, either by the Mascarene Island-continent, with perhaps an African commissure, or, perhaps, for a time with that continent directly. The South Atlantic Ocean would seem to extend far south into the Antarctic separating the Ethiopian prolongation from the South American enlargement, which included the Falkland Islands, South Georgia, and the Sandwich Group, to Graham and Alexander Lands. But our knowledge of the sea floor south of Africa is still very imperfect."

"If it be true that Ice Ages and Genial Ages were alternate in the two hemispheres, as Sir R. Ball affirms, then when the Miocene Southern Ice Age was at its height, the life in this southern continent would be driven towards or across the equator, and when in the late Miocene and in the Pliocene, the warm period (corresponding to the growing cold period of the northern hemisphere) was advancing, and the land surface fit for peopling was increasing, there would be a slow return to the Antarctic land. Whether or not there was such a cold period, there must have succeeded a very mild age—almost certainly during the height of the glacial age of the northern hemisphere—to enable the fauna and flora now common to the terminal areas of the three great continents to develop on a southern land and to intermingle."

"The monotremes and marsupials in Australia are supposed by Mr. Wallace to have come to Western Australia at a very ancient period from Asia, *viâ* a land connection across the Java Sea, and to have entered East Australia only in the Tertiary age after the union of the two islands. Nearly all our fossil remains, however, of these groups are found in East Australia, and their present distribution is in northern Austro-Malaya and Australia. Now there have been found in Patagonia, as already stated, in early Eocene times fossil remains, nearly allied to the carnivorous Thylacine of Tasmania and the dasyures, that occur both in Pliocene and Pleistocene beds in Australia, or live now in Australia and Tasmania. No fossil remains of these southern forms have been found elsewhere out of Australia and Patagonia. It is not therefore at all improbable to suppose that the South American Thylacine-like forms multiplied and developed in the Southern Continent during the warm age of the southern—and reached East Australia from that continent, then spread north through Tasmania into New Guinea and the Papuan Islands. Why they are not found in New Zealand is difficult to say; some temporary subsidence or other barrier may probably have prevented their reaching it. It does seem to me strange if the marsupials reached Australia *viâ* the Java Sea, Timor, and the belt of the Austro-Malayan Islands to the west of it, that with the exception of a *cuscus*, which may not improbably have been introduced, there are no marsupials in any of the South-Eastern Austro-Malayan Islands, where there are no enemies not found in New Guinea and Australia, especially in Timor, which is so Australian in its climate and vegetation. The ancestors of the present marsupials in South America, which have no near affinity with the present Australian forms, came no doubt *viâ* North America from Europe. The ancestors of the cassowaries, moas, and kiwis are supposed by Mr. Wallace to have come from New Guinea into the north of East Australia, and to have spread thence to New Zealand in Cretaceous times. Again the Eocene of Patagonia has produced the remains of giant struthious birds—*Brontornis burmeisteri*—which can have been the ancestors on the Antarctic Continent, not only of the Australian and New Zealand forms, but of all the tridactile forms—of the *Æpyornis* of Madagascar, as well as the Neotropical rheas. Recent remains of *Æpyornis* received at the British Museum show in the tibia, or leg bones especially, a very close resemblance to that of the moa. The metatarsi of the moa and *Æpyornis* also show many points in common. The Madagascar, the Australian, and the New Zealand Ostriches would at least seem to have had a common ancestor."

"That a current of life has flowed from south to north, as well as *vice versâ,* has strong support lent to it by the results of Sir William Macgregor's recent botanical collections in New Guinea. In the highland vegetation of that country, along with an extensive display of heaths and whortleberries—forms of vegetation which are scanty in Australia—there is also a marked preponderance of far southern types, belonging to Australia, New Zealand, and Antarctica. In Borneo also have been found plants common to the Papuan highlands, and also plants from high southern latitudes. So many plants from high southern latitudes of common origin, typical of Tasmania, of continental Australia, of the Southern Ocean, and of Patagonia, point to a land connection of portions of New Guinea with an Antarctic continent. As there are, moreover, abundant evidences of great volcanic action over all the region, in New Zealand, South America, Mascarenia, and the Antarctic Islands, the permutations and combinations of the ups and downs of these lands, the openings and closings of the gates, paths, or stepping stones, are beyond our computation."

Mr. Forbes sums up in these words:—

Shortly, therefore, 'it is highly probable,' as Mr. Blanford says, 'that many forms of terrestrial life . . . originated in the southern hemisphere; and . . . it is far from improbable that the Antarctic continent was the original area of development.' It seems to me, therefore, highly probable that Professor Huxley's divisions of the Globe, in which he is followed by Professor Kitchen Parker, according to the distribution of life into a northern and into a southern land—an arctogœa and a notogœa—will turn out to be the two fundamental biological divisions of the Globe. That there was a centre of development at both poles, and the wanderings and migrations of the fauna and flora, northwards or southwards, from age to age, and from one side of the Equator to the other, were regulated by glacial and genial periods, and from east to west by the elevation and subsidence of an extensive land, in the southern hemisphere as in the northern.

These deductions as to an Antarctic continent, made on biological grounds, are supported by the depth of the circumpolar sea, so far as it is known. The submarine shelf of the Austral land slopes northward all round the shores of the known lands more gently than along any other coast, and would seem to indicate that, if elevated, the land would form in great extent a continuation of the three primal ridges of the globe southward, coalesced and spread out round the Pole, with, between these arms, the terminations of the great and permanent ocean troughs. How far these hypotheses may be substantiated or refuted by future researches it is difficult to say; but the discovery of *Aphanapteryx* bones on the Chatham Islands must always remain an important fact in the solution of this most difficult and intricate question."

II.—The Supposed Quaternary and since Submerged Volcano of Mergellina, at Naples.[1] By Chev. W. P. Jervis, F.G.S., etc.

On entering the Bay of Naples by steamer the first thing which must have struck every geologist—leaving aside Vesuvius for the present—is the line of flat-topped hills stretching along the northern shores of the Bay, from Cape Posillipo to the Chiatamone, above the Castel dell'Uovo, their summits in no place exceeding from 160 to 200 metres in height, except at the Castel Saint'Elmo (224m.) while they extend inland from the Vomero to the culminating point at the old Camaldoli convent, above Pianura (455m.). These hills are essentially constituted of irregular strata of ochreous-yellow volcanic tufa of various tints, passing on the one side to pale yellowish white, and on the other to yellowish brown. This tufa is accompanied by frequent alternating beds of extremely fine volcanic ashes, and others often exclusively formed of impure-white or ash-grey pumice in angular pieces, ranging from less than a quarter-of-an-inch to several inches across, and adhering slightly together, though easily separated by the hand. Fragmentary pumice also exists in a certain proportion as a constituent of the volcanic tufa itself, in such case partaking in general of the coloration of the rock in which it is imbedded, being of a yellowish brown, and only in some places white, for instance near Piedigrotta. Sometimes the pumice is dark yellowish-brown, this variety, as well as the paler kind, being much decomposed, or what might be called in ordinary language rotten, so as to crumble when an attempt is made to detach it from the enclosing rock, for it is only when the pumice retains its original whitish or ash-grey appearance that it preserves any consistency or is of any economic value.

It will be immediately observed, on the most superficial examination, how remarkably irregular is the bedding of even the thickest strata, as they rapidly thin out, and often disappear altogether, to be replaced by others of very different lithological structure. As if to add to such irregularity, the dip of the beds is very varying and inconstant; in one spot it appears to be horizontal, a few yards beyond it is not unfrequently undulating, and further on inclined at a high angle—suggesting the probability of upheaval and giving-way of the strata through local volcanic agency, exerted at a very slight depth below the surface and frequently repeated.

---

[1] From the "Mediterranean Naturalist," October 1, 1892.

In quarrying the tufa as a building-material, invaluable on account of its cheapness (five pieces of a roughly parallelopipidal shape, together measuring about two cubic feet, being worth only a franc) —the greatest difference is found to exist in the coefficient of resistance to pressure and crushing strain, according to the locality and series of beds whence the stone is procured. One point, however, is found in common; it was all bedded as a littoral deposit and in shallow sea-water; in confirmation of this, large oyster shells may be sometimes met with in it. Lead-grey volcanic tufa is largely developed at the southern entrance to the Bay of Naples, around Sorrento, but it is nowhere to be met with on the north side of Vesuvius, or beyond the region I am describing in the direction of Pozzuoli or in the islands of Procida or Ischia.

Topographically the tufa hills of Posillipo and Naples continue in the direction of the old Camaldoli convent, in which neighbourhood scoriaceous and other lava is largely developed; in other directions these hills have no connection with any others, for towards Vesuvius and in the direction of Caserto they die off gradually, and the plain at their foot is but slightly above the sea-level. From Cape Posillipo as far as the Vomero, above the Grotta di Pozzuoli, the hill is saddle-shaped, with a long, narrow ridge at the summit, and sloping down at a considerable angle on each side to the base. At the distance of half-a-mile from the mainland beyond Cape Posillipo is the little islet of Nisita, 180m. high, which is simply a small volcanic cone, with a crater broken down on the side looking towards the entrance of the bay, the rock consisting of volcanic tufa.

It has always been a question to me whence this prodigious mass of tufa overlooking the Bay of Naples was ejected. Certainly not from Vesuvius or Monte Somma, far less from certain other volcanoes, such as the Solfatara, the Astruni, or Agnana, which have not the least topographical connection with the hills of which I am speaking, and no denudation has taken place to authorize such a supposition; most improbably also from Nisita, which, besides its insignificant proportions, occupies too eccentric a position. For my part I have for many a long year been led to believe that this tufa was produced by a volcano situated at a short distance from the Mergellina (part of Naples), but now submerged and no longer recognizable. Possibly we may be shortly able to clear up this difficulty, a most unexpected discovery having been recently made in the very heart of Naples, and one to which I am led to attribute considerable geological importance.

At the present time a large main sewage drain is being driven through the soft tufa rock from the south-eastern part of the city to the vicinity of Fuorigrotta, outside the city to the north-west. Under the Villa Montfort, at the lower end of the Parco Grifeo, close to the Corso Vittorio-Emanuel, the sewer is situated at the level of 13m. 70cm. above the sea; 250m. farther north, close to the new International Hospital, it is slightly more than 13m. above the sea-level; the surface of the ground above being respectively 100m. and 65m. at the points alluded to. Just under the Villa Montfort trachyte rock was met with, 40m. of it having been already bored through, while at the surface not a trace of such rock was ever suspected to exist, volcanic tufa alone being seen; nor did it ever come under any person's observation that trachyte should anywhere be met with in the tufa hills I am describing. The trachyte, which I have carefully examined, is of a dark lead-grey or bluish colour, and equal to the hardest and most compact kind found in any part of the Phlegræan Fields, being identical in structure to some met with at Pozzuoli, and like it enclosing small crystals of sanidine or glassy felspar. Attiguous to the trachyte, and for a certain distance from it to the south-east, the tufa is very pumiceous, and large loose blocks of trachyte of a yellowish tinge are to be found imbedded in the midst of the tufa, from which they do not essentially differ in colour. Sometimes the tufa adheres firmly to the trachyte, which might lead us to suppose that the latter must have fallen on the surface of the tufa before it had had time to be perfectly cooled. M. Giusti, the engineer in charge of the works at this point, kindly gave me the following data. After leaving the ordinary yellow tufa common to these hills, some beds of good yellow tufa were pierced, then rather clayey tufa; after which dark-yellow tufa containing large fragmentary pieces of undecomposed pumice, a variety peculiar to this neighbourhood; then a gentle synclinal of white tufa, each of these several beds being but a few metres in thickness. After this followed 30m. of pumiceous tufa, containing large loose blocks of trachyte, followed by the trachyte rock *in situ* above alluded to.

Have we not here the evidence of the existence of a volcanic eruption of Quaternary age, though it cannot yet be decided whether it ever reached the surface, or whether there were not some lateral veins, or a blind dyke, which forced its way up through the already existing tufa. The subject offers much interest, and I hope some day to be able to communicate further information regarding it. I am led to conclude that the central crater of this volcano must have been situated within a mile of the present coast-line in a spot now occupied by deep water, the cone having subsided since the Quaternary period. Should my conjecture be found admissible we might apply the name of "Mergellina volcano" to this trachytic ejection, and we might then be authorized to regard the tufa hills of Naples and Posillipo as having had their origin thence. Both the trachyte and the yellow tufa are rocks common to all the volcanoes of the Phlegræan Fields and the neighbouring islands, while leucitic rocks characterize Monte Somma, and augite and leucite Vesuvian rocks.

While speaking of the neighbourhood of Naples I may just give the results of a few very careful observations I made this spring of the temperature of several thermal springs and fumaroles, and compare them with former studies.

Casamicicola, Island of Ischia.—*Acqua del Gurgitello,* February 1869, 84°. c. (Jervis); 10th May, 1892, 84°. c. (Jervis).

Lacco Ameno, Island of Ischia.—*Acquadella Rita* 1833, 70°. c. (De Rivaz); 1835, 61°. c. (Guarini); 11th May, 1892, 66°. c. (Jervis).

Barano d'Ischia.—*Fumarola di Saint' Angelo,* on the beach; February 1869, 100° c. (Jervis); 11th May, 1892, 100°. c. (Jervis).

Casamicicola.—*Stufe* or *Fumarole di Castiglione* 1822, upper fumarole 56°. c. lower fumarole 66°. c. (Del Giudice); 11th May, 1892, lower fumarole 56°. c. (Jervis).

Pozzuoli—*Fumarola della Bocca della Solfatara,* February 1862, 93°. 4—96°. 5 c. (Deville); June 1865, 77°.—96°. c. (Deville); 1865, 96°. c. (Fouqué); July 1867, 115°. c. (Gorceix); January 1869, 92°. c. (Jervis); 12 May, 1892, 95°. c. (Jervis).

Naples.—*Stufe di San Germano,* 1856, 64°.—93°. c. (Deville); 1857 and 1882, 61°.—97°. c. (Deville); 1857 and 1862, 61°.—97°. c. (Deville); July 1869, 85°.—96°. c. (Deville); May 1892, 86°. c. (Jervis).

Naples.—*Acqua del lago prosciugato di Agnana,* May, 1892, 69°.—73°. according to place (Jervis).

Naples.—*Grotta del Cane,* May 1892, 38°. c. (Jervis).

TURIN, *September,* 1892.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—March 22nd, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Jaw of a new Carnivorous Dinosaur from the Oxford Clay of Peterborough." By R. Lydekker, Esq., B.A., F.G.S.

The Author describes a fragment of the left side of a lower jaw of a Carnivorous Dinosaur from the Oxford Clay of Peterborough, indicating a new genus and species, which he names *Sarcolestes Leedsi.*

2. "On a Mammalian Incisor from the Wealden of Hastings." By R. Lydekker, Esq., B.A., F.G.S.

In this paper a small rodent-like tooth from the Wealden of Hastings, belonging to Sir John Evans, K.C.B., is described. It is probably the front tooth of one of the mammalian genera found in the Purbeck Beds, as may be gathered from American specimens.

3. "On an Intrusion of Muscovite-biotite-gneiss in the South-eastern Highlands, and its accompanying Thermo-metamorphism." By George Barrow, Esq., F.G.S., of the Geological Survey. (Communicated by permission of the Director-General of the Geological Survey.)

The area to which this papers refers lies in the north-eastern part of Forfarshire, and is drained by the two Esks. The Author first describes the distribution, mode of occurrence, and petrological characters of the intrusive masses. In the north-western portion of the area the intrusive rock is always a gneiss, and occurs in thin tongues which permeate the surrounding rocks. Towards the south-east these tongues amalgamate and form large masses, in which the foliation is less marked. Moreover, in this direction the large masses are often fringed with pegmatite, especially on their southern and eastern edges. Where the rock is a gneiss, it is composed of oligoclase, muscovite, biotite, and quartz, but contains no microcline. As the gneissose character becomes less marked, the oligoclase diminishes in amount, and microcline begins to appear, especially towards the margins of the masses. In the most south-easterly of these microcline is greatly in excess of oligoclase.

The differences in structure and composition of these masses are believed by the Author to be due to the straining off of the crystals of earlier consolidation during intrusion under great pressure. The still liquid potash-bearing portion of the magma was squeezed out and forced into every plane of weakness in the surrounding rocks; and that portion of it which contained the highest percentage of potash finally consolidated as pegmatite.

Special attention is directed to the distribution of pegmatite. This rock is widely distributed in the Southern Highlands, and cuts across every known system of folding. It is consequently newer than any member of the metamorphic series.

The surrounding metamorphic schists are next dealt with. These are remarkable for their highly crystalline condition, and also on account of the presence of many minerals known to occur in regions where thermometamorphism has taken place. The characters of the more important minerals are described in detail. The rocks of the metamorphic area become less and less crystalline as they are followed towards the Highland border. Three zones, characterized respectively by the minerals sillimanite, cyanite, and staurolite, have been roughly mapped. The more important rocks found in these zones are described in detail, and evidence is given to show that the boundaries between the zones do not in all cases coincide with the strike of the rocks. Thus, a thin bed of quartzite, which retains its character in consequence of the simplicity of its chemical composition, may be followed through all the zones; whereas the bed adjacent to it is in the outer zone a staurolite-schist, in the intermediate zone a cyanite-gneiss, and near the contact with the igneous rock a coarse sillimanite-gneiss. Evidence is given to show that the original rocks formed a sedimentary series.

The phenomena are compared with those of other areas where thermometamorphism has taken place; and the conclusion is reached that the differences are of *degree* rather than of *kind*. The special features of the area in question are attributed to the depth at which the change was produced.

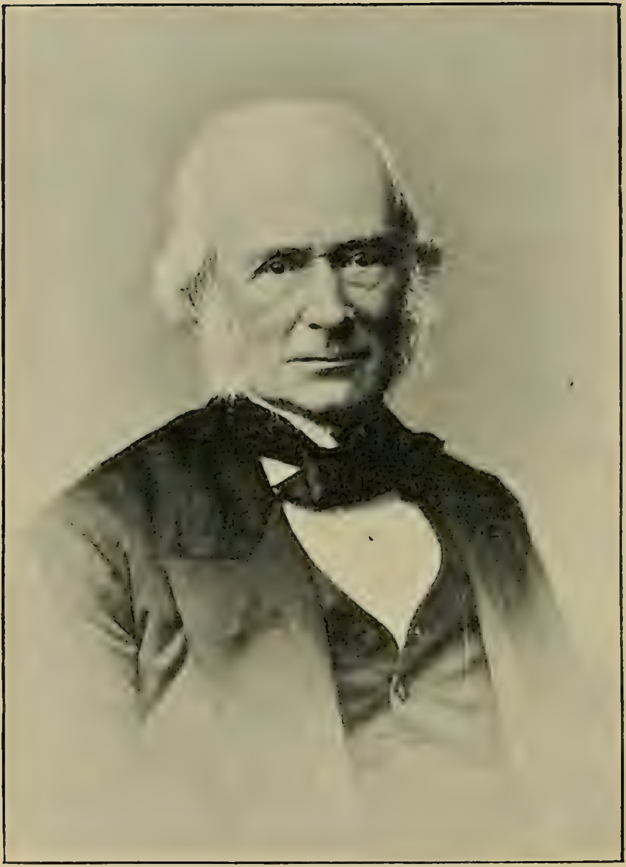
The singular Fucoid-like impression, long known from the older Palæozoic Rocks of North America, under the name of *Arthrophycus Harlani*, has just been sent home from the Gold-Coast-Colony, West Africa, by Mr. Ferguson to Professor J. W. Judd, F.R.S., who has presented a specimen to the British Museum (Natural History), Cromwell Road, S.W.

OBITUARY.

THOMAS GABRIEL BAYFIELD, OF NORWICH.

Born 17 January, 1817. Died 27 March, 1893.

Many who are engaged in scientific and literary work in the city and county of Norwich and Norfolk will learn with regret the death of Mr. Thos. Gabriel Bayfield, which occurred on 27 March, at his residence, Bracondale. The deceased gentleman, who had attained his seventy-seventh year, was the son of an ironmonger, who carried on an old-established business in Magdalen-street. As a lad he was sent to Mr. Brooke's school, at the Greyfriar's Priory, but was afterwards removed to the seminary conducted by Mr. Norman, in Golden Dog-lane, where he acquired a good knowledge of Latin, Greek, mathematics, and the ordinary English subjects. Upon leaving school, at the age of fifteen, he entered the Magdalen-street establishment, and worked for two years with his father, who had originally intended him for the medical profession. His father died in 1834, and young Bayfield remained to assist in the business, which for many years was carried on under the style of Ann Bayfield and Son. In his school-days the lad formed the acquaintance of B. B. Woodward, afterwards Queen's librarian, and S. P. Woodward, the subsequent author of a Manual of the Mollusca, both sons of Samuel Woodward, of Norwich, and from them he imbibed a love for archæology and natural history. Possessing an enquiring mind and a memory of remarkable retentiveness, he amassed a rich store of knowledge on archæological, geological, and other scientific subjects. He was regarded as an authority on ancient seals, and rendered great assistance to Dean Goulburn in the compilation of his work on Norwich Cathedral. Mr. Bayfield devoted much attention to electro-types, of which he made many specimens; he also spent considerable time in botanical research, and was much sought after by local scientists, by whom he was greatly respected. In geology he laboured at the Chalk and Norwich Crag, and made a valuable collection of fossils, those from the Chalk being subsequently acquired by the British Museum. He was one of the most active members of the Norwich Geological Society, an enthusiastic member of the Norwich Science Club founded by Dr. J. E. Taylor, whom he succeeded as President, and he was also President of the Norfolk Naturalists' Society. Upon relinquishing business, about sixteen years ago, Mr. Bayfield obtained the appointment of Master of the Blind School, but after discharging the duties of that office for about seven years his health failed, and he retired into private life. He still retained an affection for scientific pursuits, and took great interest in his large and varied collection of antiquities. Mr. Bayfield leaves a widow (the eldest daughter of the late Samuel Woodward), a son, and two daughters. —*Eastern Daily Press.*



Yours very truly
Joseph Prestwich

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. VI.—JUNE, 1893.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists. No. 8.

Professor Joseph Prestwich, D.C.L., F.R.S., F.G.S., F.C.S., Assoc. Inst. C.E., Corr. Inst. France, etc., etc.

(With a Portrait.)

OUR venerable friend Professor Prestwich, who has now attained his 82nd year, may serve as an admirable illustration of the law of "the survival of the fittest," for years have failed to dim either the brightness of his eyes, or the clearness of his intellect; the only sign of advanced longevity being the inability to undertake those long walks over the Chalk Hills around Shoreham, in which he, till lately, delighted to indulge.

Mr. Prestwich is one of the few survivors of the second generation of great British Geologists, who were led by Buckland, Sedgwick, Conybeare, Fitton, De la Beche, Murchison, Scrope, and Lyell; and who had for his contemporaries Agassiz, Phillips, Owen, Darwin, Godwin-Austen, Forbes, Morris, Ramsay, W. Smyth, S. V. Wood, Wetherell and Edwards, all of whom have, alas, passed away, whilst his older surviving geological friends Sir John Evans, Rev. O. Fisher, T. Rupert Jones, R. Etheridge, and others, are all his juniors. During his long life Professor Prestwich has witnessed great changes of views and vast increase of knowledge in his favorite science of geology. In his boyhood, when Buckland began to lecture at Oxford, on the "new and curious sciences of Geology and Mineralogy," geologists had only begun to suspect the importance of cave-remains, and of the discovery of bones of recently-extinct mammalia. Although his earliest triumph was won by his memoir on "The Geology of Coalbrookdale," and his later studies led him to become the first authority on the water-bearing-strata around London, yet he was destined to be the investigator who first demonstrated to English men of science that the flint implements, found in the valley of the Somme, in contiguity with fossil mammalia, were genuine works of man, contemporaneous with extinct animals, a conclusion which might readily have been reached long before, but for the absolute prepossession in favor of the views of man's limited existence upon the earth which were then current.

The descendant of an old Lancashire family, Joseph Prestwich was born at Pensbury, Clapham, near London, March 12th, 1812.

He received his early education near London, passed two years at Paris in a school attached to the College Bourbon, thence he was transferred to Dr. Valpy's at Reading, and finally entered University College, Gower Street, then just established.

He was a diligent student under Dr. Turner and Dr. Lardner in the Chemical and Natural Philosophy Classes, somewhat to the neglect of his classical studies.

At that time a student of geology had to be his own master and teacher. There was hardly a text-book and no public lectures, except three lectures on mineralogy and geology forming a part of the course of forty lectures by Dr. Turner on chemistry. The proximity of the British Museum he found of great advantage for the study of the geological and mineralogical collections between lectures.

Whilst still a student at University College, he started a Society amongst young men of his own age (from 18 to 20), each of whom engaged in turn to deliver a lecture on Chemistry or some branch of Natural Philosophy. There were about fourteen members who met regularly in rooms in Surrey Street, Strand, where they had a small Laboratory, and styled themselves the "Zetetical Society." But by degrees, owing to professional and business engagements, the Society was broken up.

Mr. Prestwich's own tastes would have led him to adopt a profession, but circumstances caused him to enter into business in which he remained closely engaged until the year 1872. He was frequently in France and Belgium between 1836 and 1850, which gave him the opportunity of making the acquaintance of most of the French geologists, including Deshayes, Hébert, Chas. D'Orbigny, Lartet, D'Archiac, Desnoyers, Constant Prevost, Delesse, De Verneuil, Omalius d'Halloy, Dumont, de Koninck, and later on with Gaudry, Daubree, Belgrand, Gosselet, Nyst, Dupont, and others; many lasting friendships were thus established.

Mr. Prestwich's first paper was on the "Gamrie Ichthyolites," to which the then scarcely known Hugh Miller, of Cromarty, had just directed attention. His holidays in 1831-32 were spent in the investigation of the coal field of Coalbrook Dale, and his memoir thereon, with the description by his friend Professor Morris of various new species of plants and mollusca, showing the horizons to which each of them belonged, was published four years later in the Transactions of the Geological Society of London.

This paper was followed by a series of others, printed in the Quarterly Journal of the same Society, on the structure and organic remains of the several groups of strata of the London and Hampshire Tertiary Basins. In these memoirs he established the existence, at the base of the known deposits, of a marine formation which he designated the "Thanet Sands," proved the synchronism of the barren mottled and plastic clays of Reading with the fluvio-marine beds and fossiliferous pebbly sands of Woolwich; and showed that the London clay was not the equivalent of the Bracklesham and Barton beds, but that it occupied a lower zone, and was synchronous with the Bognor beds of the Hampshire Basin.

This re-arrangement of the English Eocene series necessitated a revision of their correlation with the same strata in France and

Belgium. Mr. Prestwich showed, on the evidence of their organic remains, that the Thanet Sands were the equivalent of the lower *Système Landenien* of Dumont, whilst the Woolwich and Reading beds corresponded with the upper *Landenien*; the London Clay with the *Système Ypresien*; the Bracklesham Sands with the *Système Bruxellien*; and the Barton with the *Lackénien*. In the Paris basin, Mr. Prestwich could not recognise the Thanet Sands, but considered that the marine sands of Bracheux, which also repose on the Chalk, were the equivalent of the lower estuarine sands of Woolwich, and of the more entirely marine green sands of Richborough; and he further showed that the sands under the *Physa* beds at Rilly should be referred to the same zone, whilst the *Physa* bed itself he considered to be a local deposit intercalated in the lower part of the same Woolwich series—a conclusion contested, at first, by the French geologists. The London Clay he placed approximately on the level of the *Sables Coquilliers* of D'Archiac, whilst the *Calcaire Grossier*, before referred to the London Clay, was identified by him with the middle Bracklesham and Bagshot Sands; and the Barton beds with the *Sables des Beauchamp.*

In the meantime, Mr. Prestwich's attention had been directed to the more recent superficial or Quaternary deposits, and it was while engaged on these that the discoveries of M. Boucher de Perthes relating to the palæolithic flint implements attracted his notice. These discoveries had been known to geologists, as were those relating to analogous discoveries elsewhere in caves, for many years; but they failed to satisfy geologists, and were received with incredulity both in England and France.

Mr. Prestwich had been intending for some years to examine the evidence personally, but it was not until 1859, at the instigation of his friend, the late Dr. Hugh Falconer, who had long held the same views with respect to the probable antiquity of man, that he was able to undertake the investigation of the drift deposits of the Valley of the Somme. By this inquiry to which he invited the coöperation of Sir John Evans, Godwin-Austen, and other geologists, he quite satisfied himself and them that the flint implements were the work of man, and that they were lying in undisturbed beds of sand and gravel, in conjunction with the remains of extinct mammalia, as had been asserted by Boucher de Perthes and Dr. Rigollot; and his paper before the Royal Society at once gained acceptance for his views amongst geologists.

Mr. Prestwich, in a subsequent paper, showed that the flint implements occurred on two or more levels, which he designated as the "high- and low-level valley gravels," and that the former were formed and deposited before the excavation of the valley in which they occurred, and therefore vastly extending the antiquity of these deposits. The loess with which these gravels were associated was shown not to be the result of one flood or of lakes, but to belong to different stages of the formation of the valley; to be, in fact, a silt deposited during floods of the old rivers at several periods of their existence.

As a cognate subject bearing on the Antiquity of Man, Mr. Prestwich drew up in conjunction with Mr. Busk, at the request of the Committee of Investigation, the Report on Brixham Cave, published in the "Philosophical Transactions" in 1872. Subsequently he brought out the first of his papers on the Pliocene and Pleistocene series, commencing with the Crags of Norfolk and Suffolk, between which and the Crags of Belgium he instituted a comparative examination of their organic remains; while in another paper, also read before the Geological Society, he has shown at how recent a date some of the important disturbances affecting Portland, and the valley denudation of the South of England have taken place.

These were followed by a paper read before the Institute of Civil Engineers, "On the Geological Conditions affecting the Construction of a Tunnel between England and France," in which he discussed the lithological characters, range and dimensions of the several formations on the two coasts, and showed that the Palæozoic strata offered the safest passage, but that their depth was a very formidable bar. He afterwards brought before the same institution a paper "On the Origin of the Chesil Bank," in which, differing from previous observers who attributed it to shingle, drifted from the Dorset and Devonshire Coasts, he showed that it was due to the wreck of the old "Raised Beach" of Pleistocene age, that he had before described and of which a remnant still exists, twenty-five feet above the sea-level, on the Bill of Portland, and which formerly stretched thence to the Devonshire and Cornish Coasts on one side and to Brighton on the other.

In 1874, in another paper to the Royal Society, he brought together and reduced to a common standard all the observations on Deep-sea Temperatures made between the years 1749 and 1868, from which he deduces certain facts with respect to the flow of deep-seated currents, the position of the bathymetrical isotherms, and their bearing on some geological phenomena.

When the Royal Coal Commission was appointed in 1866 Mr. Prestwich was one of its most prominent members, and in that capacity he drew up two of the sub-reports—the one "On the quantity of Unwrought Coal in the Coal-fields of Somerset, and the other, "On the Probability of finding Coal under the Newer Formations of the South of England," of which he took a favourable view. He was also one of the members of the "Royal Commission on Metropolitan Water Supply of 1869."

At a meeting of the British Association, at Swansea, in 1880, he brought before the Geological section some observations which tended to show that the South of England, and probably great part of Western Europe, had been submerged at a very late geological time, and that this event marked the line between the great Mammalia of the Quaternary period with Palæolithic man, and man of the Neolithic or recent period. These views, however, met with considerable opposition. At the York meeting in 1881, he gave an outline of his researches on the strata immediately underlying the glacial series; and in another paper he contested the generally accepted theory of volcanic action, that it is due to the agency of high-pressure steam in the Volcanic foci, and contended on the contrary that water was a secondary and not a primary cause in this action, and its action he showed to be the necessary consequence of the hydro-geological structure of volcanic mountains.

Mr. Prestwich was appointed by the Vice-Chancellor of the University, Dean Liddell, to succeed Professor Phillips in the chair of geology at Oxford in 1874.

On theoretical points Prof. Prestwich holds anti-uniformitarian views, some of his reasons against uniform action in all time being given by him in his Inaugural Address at Oxford in 1874, and in his "Geology." He also opposes Croll's time theory.

Professor Prestwich has published three lectures on the Geology of the neighbourhood of London, entitled "The ground beneath us," and a work on the "Water-bearing Strata around London," with a view to fresh sources of supply for the Metropolis; also a pamphlet on the Water supply of towns, more especially of Oxford.

In 1876, in investigating the conditions for a better water supply, he pointed out that there was under Oxford an abundant source of mineral water, allied to but stronger than those of Cheltenham and Leamington. The *vexata questio* of the "Parallel Roads of Glen Roy" next engaged his attention, and this was followed by several other papers, amongst which may be mentioned those on "Underground Temperatures" and on "Volcanic Action."

As far back as 1849 the Geological Society awarded Mr. Prestwich the Wollaston Medal for his researches on the Coalfield of Coalbrook dale, and those on the Tertiary districts of London and Hampshire. In 1865 the Royal Society awarded him a Royal Medal for his contributions to Geological Science, and more especially for his paper in the Philosophical Transactions, "On the Occurrence of Flint Implements associated with the Remains of Extinct Species of Mammalia in beds of a late Geological Period in France and England;" and that "On the Theoretical Considerations on the Conditions under which the Drift Deposits containing the remains of Extinct Mammalia and Flint Implements were accumulated, and on their Geological Age."

Professor Prestwich served the office of President of the Geological Society of London from 1870–72. He was made a Vice-President of the Royal Society, 1870–71. In 1874 the Institute of Civil Engineers awarded him a Telford Medal and premium for his paper on the "Geological conditions affecting the construction of a Tunnel between France and England."

At the annual *Réunion* of the Geological Society of France, at Boulogne, in 1880, Professor Prestwich was elected President of the meeting; and in 1885 the Institute of France elected him a Corresponding Member of the Academy of Sciences. In 1886 the first vol. (Chemical and Physical) of his work on "Geology" was published by the Clarendon Press. The second vol. (Stratigraphical and Palæontological) with a Geological Map of Europe appeared in 1888. In the same year the University of Oxford conferred upon him the honorary degree of D.C.L. He was elected President of the "Congrès Géologique International," which held its session in London in September, 1888. His latest papers were read before the Geological Society of London, "On the pre-Glacial Drifts of the South of England, with a view to determine a base for the Quaternary Series, and to ascertain the Period of the Genesis of the Thames Valley" (see Quart. Journ. Geol. Soc. 1890, vol. xlvi. pp. 84, 120, 155). "On the Age of the Valley of the Darent and remarks on the Palæolithic Flint Implements of the District," etc., in which he shows that on the high chalk plateaux of Kent there are flint implements of a peculiar rude type fashioned by a race of men of much greater antiquity than those who made the implements of the Thames and Somme Valleys (*op. cit* vol. xlvii. 1891, pp. 126–163). "On the Raised Beaches and 'Head' or Rubble-drifts of the South of England," etc. (*op. cit.* vol. xlviii. 1892, pp. 263–343). "On the Evidences of a Submergence of Western Europe at the close of the Glacial Period," etc. (Royal Soc. Proc. March 9, 1893).

Since Professor Prestwich's retirement from the Oxford Chair, in 1888, he has mostly resided at his country seat, Darent Hulme, Shoreham, Kent, a charming house built to his own taste some 25 years ago, full of quaint geological pictures by Ernest Griset; and even in its architecture illustrating geology at every turn. Here he divides his time between his garden and his library, always in association with Mrs. Prestwich, his ever-constant companion and most enthusiastic scientific friend, adviser, and co-worker, the beloved niece of the late Dr. Hugh Falconer, F.R.S. H. W.

II.—ON FOSSILS APPLIED AS CHARMS OR ORNAMENTS.

By THE EDITOR.

THE summer visitor to Lyme-Regis, to Scarborough, or to Whitby, is familiar with the little *Ammonites*, mounted in silver as brooches for ladies, and may even have seen them also with heads carved, to represent coiled-up serpents, with green or pink eyes of glass, inserted by the enterprising jeweller.

Doubtless the use of these fossil shells as ornaments has been handed down from Saxon times, when "Whitby's nuns exulting told, * * * * * *

> And how of thousand snakes each one
> Was changed into a coil of stone,
> When holy Hilda prayed."—Marmion, Canto II. xiii.

Nor can it be doubted that the early Rosaries, made from the stem-joints of Encrinites, picked up on the beach, emphasised the fisherman's tradition that:—

> "Saint Cuthbert sits and toils to frame
> The sea-born beads that bear his name."—Marmion, Canto II. xvi.

Many more such legends bearing upon fossils doubtless exist, if one could but gather them up.

My friend Mr. William Cunnington, F G.S., long since drew my attention to an elegant relic illustrating the belief in the wearing of a fossil fish-tooth as a charm against evil, which prevailed in this country probably less than three hundred years ago, and as it may interest some of the readers of the GEOLOGICAL MAGAZINE, I give it, with a few prefatory remarks.

The circular enamelled palatal fish-teeth of *Lepidotus maximus*, Wagner (*Sphærodus gigas*, Ag.), from the Kimmeridge Clay of Shotover and Kimmeridge, have long been known over a very wide area of Oolitic country; they are also commonly met with as detached teeth of large size in the rémanié Neocomian bone-bed of Potton, Bedfordshire. Similar enamelled fish-teeth of *Lepidotus Mantelli* from the Wealden are also well-known in many parts of Sussex. Four hundred years ago they had attracted the attention of the learned and the curious and they were regarded as *precious stones*, being called "bufonites" or "toad-stones." This term like those of "serpents-eyes," "chelonites," "batrachites," and "crapaudines," by which they were also known, refers to the vulgar notion that these organisms were originally formed in the heads of serpents, frogs, and toads.

In Dr. Thomas Browne's "Vulgar Errors" (1646), Book 3, chap. xiii., p. 137, the author of that curious work observes:—"As for the stone commonly called a 'Toad-stone,' which is presumed to be found in the head of that animall, we first conceive it not a thing impossible, nor is there any substantiall reason, why in a Toade there may not be found such hard and lapideous concretions; for the like we daily observe in the heads of fishes, as Codds, Carpes, and Pearches, the like also in Snailes, a soft and exosseous animal, whereof in the naked and greater sort [Slugs ?], as though she would requite the defect of a shell on their back, nature, neere the head [tail ?], hath placed a flat white stone, or rather testaceous concretion.

* * * * * *

"Nor is it onely of rarity, but it may be doubted whether it be of existency, or really any such stone in the head of a Toad at all. For although lapidaries and questuary enquirers affirm it, yet the Writers of Mineralls and naturall speculators, are of another beliefe, conceiving the stones which beare this name to be a Minerall concretion, nor to be found in animalls, but in fields; and therefore Boetius de Boos referres it to Asteria, or some kind of *Lapis stellaris*, and plainely concludeth, 'they are found in fields, notwithstanding that ancient writers pertinaciously affirm that they are produced in the head of the toad.'

"Lastly, if any such thing there be, yet must it not for ought I see, be taken as we receive it, for a loose and moveable stone, but rather a concretion of the crany it selfe; for (the Toad) being of an earthy temper, living in the earth, and as some say feeding thereon, such indurations may sometimes happen; and thus when Brassavolus after a long search had discovered one, he affirmes it was rather the forehead bone petrified, then a stone within the crany; and of this beleefe was Gesner. All which considered, we must with circumspection receive those stones, which commonly beare this name, much lesse beleeve the traditions, that in envy to mankinde they are cast out or swallowed down by the Toad, which cannot consist with Anatomy." * * * * * *

Extraordinary virtues were attributed to the "toad-stone" in the 16th century; it was held to be a protection against poison, and was often set in rings. That this belief was rife in Shakespeare's time, is shown by the lines in "As you like it," Book II. 1.

> "Sweet are the uses of adversity
> Which, like the toad, ugly and venomous,
> Wears yet a precious jewel in his head."

The following is a transcript[1] of Mr. Cunnington's Note "On a Crapaudine Locket, found in St. John's churchyard, Devizes, by William Cunnington, F.G.S." "In the year 1838, the Rev. E. J. Phipps, the Rector of Devizes, made some improvements in the churchyard. The footpath, which before passed in a very irregular and unseemly manner among the graves, was diverted and carried under the wall to the East. In making these alterations much of the surface was necessarily disturbed and amongst the earth taken from an old grave was found the small locket or padlock, which is represented in the subjoined woodcut.

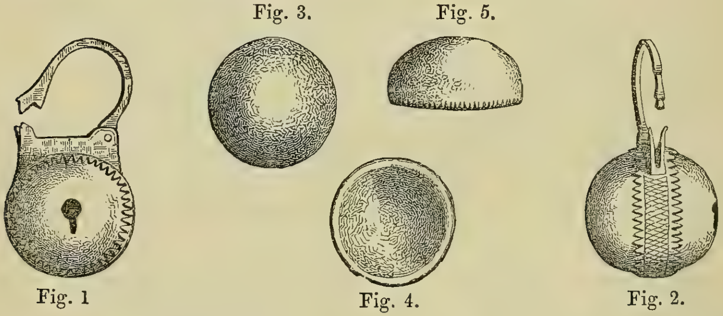


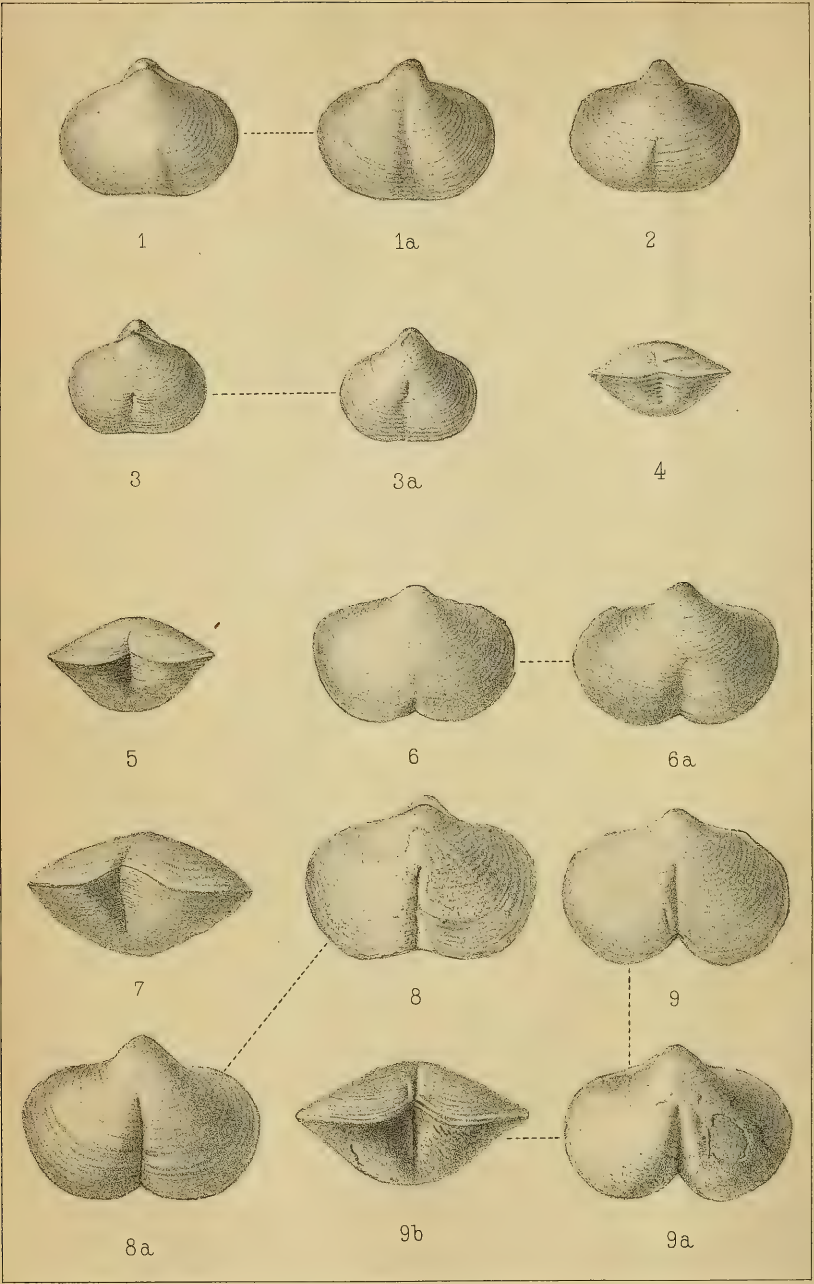
Fig. 3.
Fig. 5.
Fig. 1
Fig. 4.
Fig. 2.

Figs. 1 & 2.—"Crapaudine Locket" (fig. 1, front view, fig. 2, profile), formed of two circular palatal fish-teeth of *Lepidotus maximus*, Wagner, = *Sphærodus gigas*, Ag.
Fig. 3.—Upper and convex outer surface. Fig. 4.—Under and concave inner surface
Fig. 5.—Profile or side view, of a detached tooth of *Lepidotus.*

"It is formed of two of the round smooth (enamelled) teeth of *Sphærodus gigas* (Crapaudines) set together in an ornamental band of metal, to which the loop of the locket is attached. The metallic parts have been well gilded and are in good preservation. The key-hole is cut in the centre of one of the teeth, and some remains of the wards of the lock may still be seen inside. Mr. A. W. Franks, C.B., F.S.A., F.R.S., of the British Museum, has examined the locket, and, judging from the ornamentation, he thinks that it is not of later date than the 16th century. He has never seen a similar object."

---

[1] I am indebted to the kindness of Mr. W. Cunnington, F.G.S., for the illustration, and to his nephew, Mr. B. Howard Cunnington, of Devizes, for a copy of this paper, extracted from the "Wilts Archæological Magazine," 1870, No. xxxv., p. 249.



Edwin Wilson Cambridge.

ABNORMAL FORMS OF SPIRIFERA LINEATA.

III.—WOODWARDIAN MUSEUM NOTES.

ABNORMAL FORMS OF *SPIRIFERA LINEATA* (MARTIN).

By F. R. COWPER REED, B.A., F.G.S.

(PLATE XI.)

A SERIES of specimens showing successive stages in the development of a remarkable malformation of this species seems to me quite worth recording. The specimens are all from the Carboniferous Limestone of Settle.

The normal and common form of *Spirifera lineata* is well-known; and its varieties—*Sp. imbricata* of Sowerby, Phillips and McCoy, and *Sp. elliptica* of Phillips are likewise constantly met with in the Carboniferous Limestone. The wide gaps between the typical form and its varieties can be bridged over by the examination of a large series of individuals, so that Davidson has grouped these three forms under one specific name.

The variation from the typical form *Sp. lineata* occurs in two directions; first, in the surface ornamentation, by the thickening and widening of the concentric lines on the exterior of the valves, until they become the well-marked flattened lamellæ of Sowerby's *Sp. imbricata*; this change is also accompanied by the production of longitudinal fimbriations which are foreshadowed by fine striæ in some specimens of the typical form.

The second direction in which variation occurs is in the shape of the shell; from subcircular it becomes transversely elliptical; and the surface of the dorsal valve is ridged up into a longitudinal mesial fold, while a corresponding sinus is formed in the ventral valve, as seen in *Sp. elliptica.* There are transitional forms to be found in this case also, showing intermediate characters.

In some species of *Sp. imbricata* I have also noticed a tendency for the shell to become somewhat transversely oval. It is thus clear that in this species there is a great range of variation from the typical form, but in addition to these normal varieties I have recently detected in the Woodwardian Museum a number of specimens showing stages in the development of an abnormal yet nearly symmetrical and regularly occurring deviation. They exhibit the following characters:—

(1) A tendency to become transversely elliptical without acquiring the surface ornamentation of fine striæ found in *Sp. elliptica.*

(2) The development in the ventral valve of a mesial furrow of peculiar form. The normal ventral sinus which sometimes occurs in this species is broad, rounded and shallow, and runs from near the beak to the front edge of the shell, causing a gentle and regular sinuation of the margin.

In these peculiar individuals, however, the mesial furrow commences irregularly as a short indentation, which is continuous and of equal depth, extending in some cases nearly from the umbo to the front margin, or only from the middle of the valve; or it consists of an irregular series of indentations of varying depth; or it exists merely as a slight groove on the anterior border.

In the first stages of development it may assume any one of these forms.

Subsequently the indentation or groove becomes so accentuated as to divide the shell nearly into two lobes.

(3) Concurrently with this modification of the ventral valve, a sharp narrow depression is developed in a very similar manner on the dorsal valve: and this groove increases in depth and joins its fellow on the ventral valve at the anterior margin.

The shells in which this constriction in each valve is strongly developed have consequently a most abnormal shape.

That the malformation is not due to accidents of preservation seems obvious by our possession of specimens showing various and progressive degrees of its development. It seems that an interruption in the growth of the shell must have taken place along the median line of each valve. Whether this was owing to the presence of an internal parasite, or of some foreign body accidentally introduced; or to disease in the mantle; or to the external application of pressure during the life of the brachiopod, is not clear.

In the majority of brachiopods we know that the sinus occurs in the ventral valve and the fold in the dorsal valve, though this fold is occasionally marked by a longitudinal furrow.

But it is interesting to find in *Spirifera Urii* (Fleming) from the Carboniferous, and in the closely-allied *Spirifera Clannyana* (King) from the Permian, a slight indentation in the front edge, and shallow mesial furrows in both the ventral and dorsal valves; these, however, are regularly and symmetrically developed. Still their presence is suggestive.

There are some curious malformations in *Streptorhynchus crenistria*, from the Carboniferous, figured by Davidson in his Supplement to the British Carboniferous Brachiopoda, pl. xxxvii. figs. 4, 5. These likewise seem to be due to interruption in growth, and may be somewhat analogous to that which produced the more symmetrical grooves in the specimens of *Sp. lineata* above described.

A strangely distorted form, named *Streptis Grayii*, from the Wenlock Limestone (figured Dav. Silur. Brach. pl. xiii. figs. 14–22) has its right or left half twisted higher than the other, and consequently both valves are longitudinally divided by a sharply curved line. Were it not for the twisting, this form would closely resemble our abnormal *Sp. lineata* externally.

In a few specimens of a *Terebratula* from the Fullers' Earth of the neighbourhood of Bath in the Woodwardian Museum, indentations occur in both valves of a precisely similar appearance as those in the abnormal *Spiriferæ*; and they seem to have arisen in the same manner.

The exaggerated forms of some bilobed *Terebratulæ* and *Waldheimiæ* and of *Orthis biloba* from the Wenlock Limestone caused Baron von Buch to compare them with one another; and in spite of the great differences of internal structure, Davidson says that similar causes may easily have been at work in each case.

However, I am inclined to hold that in these specimens of *Spirifera* we have to do not with a specific variation but with an abnormality produced by something interrupting the secreting action of the mantle: whether this was a foreign substance, a parasite, a disease, or a constantly recurring similar accident, I have not sufficient data at present to decide. As far as I know no similar series of forms has been elsewhere described; and in the Woodwardian Museum we have none from any other locality.

EXPLANATION OF PLATE IX.

(The figures are numbered to indicate the successive stages in the development of the abnormal features as exhibited in the series of specimens of *Spirifera lineata* from the Carboniferous of Settle.)

Figs.	1, 1*a*.	Dorsal and ventral aspects. First and earliest stage.
,,	2.	Ventral aspect.
,,	3, 3*a*.	Dorsal and ventral aspects.
,,	4.	Anterior aspect.
,,	5.	Ditto. ditto.
,,	6, 6*a*.	Dorsal and ventral aspects.
,,	7.	Anterior aspect.
,,	8, 8*a*.	Dorsal and ventral aspects.
,,	9, 9*a*, 9*b*.	Dorsal, ventral, and anterior aspects of the most abnormal specimen.

IV.—ON A NEW SPECIES OF *DISCITES* (*DISCITES HIBERNICUS*) FROM THE LOWER CARBONIFEROUS LIMESTONE OF IRELAND.

By ARTHUR H. FOORD, F.G.S.; and G. C. CRICK, Assoc.R.S.M., F.G.S., of the British Museum (Natural History).

THE specimen which forms the subject of the present communication was obtained by one of the writers from the Carboniferous Limestone, near Dublin. Although one side of the specimen is covered by matrix, yet the other side and the periphery are so splendidly preserved, and the shell has not been distorted during fossilisation, that the characters of the fossil can be accurately determined (see Woodcut, p. 254).

The specimen belongs to M'Coy's genus *Discites*, but differs, so far as we have been able to ascertain, from any species hitherto described.

The shell is discoid, compressed laterally, and composed of rather more than two volutions, which increase rather slowly in diameter. The extreme tip of the shell, possibly a length of about one millimetre but not more, has been broken off in developing the inner whorl from the matrix. The apex is bluntly pointed, and the whorls begin in a wide curve which is free to the extent of about half a volution, from which stage the outer whorl comes in contact with the inner for the rest of the growth of the shell. Thus the young shell to the extent of about half a volution is simply curved.

The transverse section of the free or earlier portion of the shell is subcircular, becoming in the outer whorl subquadrate with the lateral angles rounded. The sides are flattened, and in the second whorl a well-marked, shallow depression occupies the outer half of the lateral area. The periphery is sulcate, bounded on each side by a subangular ridge, and is about one half the width of the side exclusive of the inner area or umbilical slope. The inner area in the young is convex and imperfectly defined; in the adult it becomes flattened, slopes outwards from the umbilicus and is nearly equal to the periphery in width.

The characters of the septa and suture-lines, as well as the length of the body-chamber, are not known, since the test is preserved over nearly the whole of the specimen.

The entire surface of the free portion of the shell bears well-marked crenulated longitudinal lines; these become less marked as the shell increases in growth and finally disappear. On the inner area they disappear soon after the commencement of the second whorl; on the sides, at the end of the first half of the second whorl; and on the periphery, some at the end of the second third of the second whorl and the rest at the end of the same whorl, *i.e.* at about one-fourth of the whorl from the aperture.

The periphery at the end of the first fourth of the second whorl, *i.e.* at the commencement of the last whorl in the specimen, bears seven nearly equidistant, longitudinal, feebly crenulated lines, one median and three on either side, the outermost on either side being upon the subangular margin of the periphery. The two lines, one on either side of the median line, disappear at about the end of the second whorl, and the rest at about the end of the second third of the same whorl (see *D* in Woodcut, p. 254).

The lateral area at the commencement of the second whorl bears seven nearly equidistant longitudinal lines. Counting from the peripheral margin, the fourth, fifth and seventh lines are crenulated, the rest plain. The third is a very feebly-marked, plain line and soon disappears, leaving at the commencement of the last whorl the wide space between the second and third lines noted below. The seventh line is followed by a plain line which eventually becomes the umbilical margin. Inside this line three other lines are seen, the middle one of the three having just lost its crenulations. The third line appears to occupy the centre of the antiperipheral area, but this point cannot be satisfactorily determined since the whole of this area is not visible at this spot.

At the end of the first fourth of the second whorl, *i.e.*, at the commencement of the last whorl in the specimen, the lateral area bears six longitudinal lines. The two outer lines are very fine and plain; the two next inner are distinctly crenulated; these are succeeded by a fine, uncrenulated, somewhat indistinct line, and then a crenulated line. Then follows the umbilical margin, which becomes more marked as the shell increases in size, and inside this margin is a single feebly crenulated line. The lines on the lateral area are equidistant with the exception of the second and third (counting from the peripheral margin), the space between these being twice as great as the space between any other two adjacent lines (see *C* in Woodcut, p. 254).

The surface of the test especially on the outer whorl is covered by very fine lines of growth, which, crossing the whorls somewhat obliquely backward, curve sigmoidally on the sides, and, becoming more pronounced at the peripheral margin, make a deep, subangular, backwardly-directed sinus on the periphery.

At the commencement of the last fourth of the second whorl, *i.e.*, at about the half of the outer whorl in the specimen, a constriction follows the course of the lines of growth and probably marks the position of a former aperture; a similar but less distinct constriction occurs at about the end of the first fourth of the last whorl.

A small portion of the test is wanting on the periphery near the aperture, and the underlying cast of the body-chamber presents a roughened surface, the rugosities increasing in size towards the centre of the peripheral area and forming interrupted, feebly-curved lines having their convexity forwards. Doubtless, these are epidermids which reproduce the surface of the mantle at this part.

The dimensions of the specimen are as follows:—

Diameter	72	mm.
Width of umbilicus (between sutures) ...	33	,,
,, ,, (,, margins) ...	about 42	,,
Greatest thickness of last whorl	about 21.5	,,
Height of last whorl at greatest diameter of shell	24	,,
Width of periphery at ,, ,,	10	,,
,, ,, commencement of last whorl	7	,,

The species with which the fossil just described may be compared are *Discites discors*, M'Coy;[1] *Discites discoideus*, de Koninck,[2] sp.; and *Discites compressus*, J. Sowerby,[3] sp.

From *Discites discors*, M'Coy, the shell under consideration differs in having fewer and more compressed whorls, fewer longitudinal lines on the sides, a sulcate periphery with longitudinal lines, and also in the direction of the lines of growth.

It differs from *Discites discoideus*, de Koninck, sp., in being less compressed, in having fewer whorls, the longitudinal lines on the lateral area crenulated, and in having longitudinal lines on the periphery.

Discites compressus, J. Sowerby, sp., has more compressed and more numerous whorls, a nearly smooth shell and the longitudinal lines on the lateral area do not reach to the end of the first whorl. Its umbilical margin is more angular and its periphery more concave.

We therefore propose to regard the specimen as representing a new species and to call it *Discites Hibernicus*. Its specific characters may be stated as follows:—

Discites Hibernicus, sp. nov.

[non *Nautilus Hibernicus*, d'Orbigny, Pal. univ., vol. i. pl. ci. figs. 2, 3. 1847.]

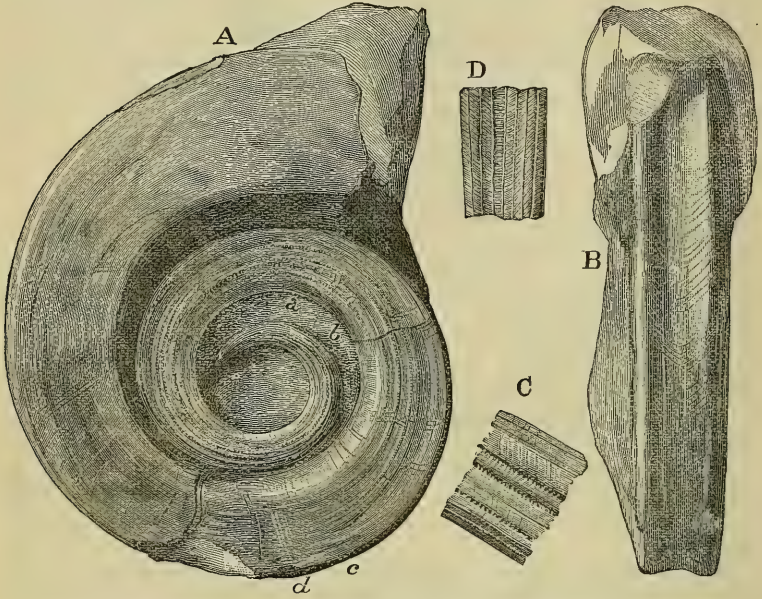
Discoid, compressed; whorls rather more than two; the first half whorl free, the rest only just in contact; whorl subcircular in section in the young, subquadrate in the adult; periphery convex in the free portion, concave in the last whorl and about one-half of the width of the side exclusive of the umbilical slope; sides flattened; surface of the young shell, also the inner and a portion of the outer whorl ornamented with longitudinal, mostly crenulated, lines; the last whorl bearing backwardly-directed, transverse, sigmoidal lines of growth, which form a deep, backwardly-directed, subangular sinus on the periphery. Septa and siphuncle not observed.

---

[1] *Nautilus* (*Discites*) *discors*, F. M'Coy, Synopsis of the characters of the Carboniferous Limestone Fossils of Ireland, 1841, p. 17, pl. iii., fig. 5. See also *Nautilus discors* (M'Coy) L.-G. de Koninck, Faune du calcaire carbonifère de la Belgique (Annales du musée royal d'histoire naturelle de Belgique, Palæont. ser., vol. ii.), part i., 1878, p. 143, pl. xxx., fig. 8.

[2] *Nautilus discoideus*, L.-G. de Koninck, *op. cit.*, p. 133, pl. xxv. fig. 3.

[3] *Ellipsolites compressus*, J. Sowerby, Min. Conch., vol. i. p. 84, pl. xxxviii., 1813. See also *Discites compressus*, A. H. Foord, Cat. Foss. Ceph. Brit. Mus., part 2, fig. 11, pp. 86 and 91. *Nautilus* (*Discites*) *mutabilis*, M'Coy, *op. cit.* p. 18, pl. iii., fig. 7, is a synonym of Sowerby's species.



Discites Hibernicus, sp. nov., Lower Carboniferous Limestone, near Dublin.—
A, lateral view of the type-specimen; natural size.
B, peripheral view of the same; natural size.
C, lateral aspect of the portion of the whorl between the letters *a* and *b* in A; somewhat enlarged.
D, the portion of the periphery between the letters *c* and *d* in A; somewhat enlarged.

V.—On the Thickness, Expansion, and Resulting Elevation of Marine Deposits.

By the Rev. O. Fisher, M.A., F.G.S.

When one refers back to such a paper as that by Babbage on the Temple of Serapis at Pozzuoli,[1] one feels humiliated by the little advance which has been made in certain branches of dynamical geology within the last sixty years. That paper contains a full and elaborate account of the plan and history of the Temple and of the remarkable changes of level which its site has undergone; and the author speculates among other causes upon the expansion and contraction of the underlying rocks, owing to changes of temperature arising from its being situated in a volcanic district, and he is thence led to speculate on the larger question of the depression and elevation of regions of the earth's surface through the fall and rise of the isogeotherms, caused by denudation and deposition respectively. He concludes his paper (which he had kept by him for many years) with the following sentence: "It may, however, be remarked that, whilst the principles on which it is founded are really existing causes, yet the sufficiency of the theory for explaining all the phenomena can only be admitted, when it shall have been shown that their power is fully adequate to produce all the observed effects."

---

[1] Read March 12, 1834; under which date see full abstract in Proc. Geol. Soc. vol. ii. p. 72. For paper in full see Journ. Geol. Soc. vol. iii. p. 186.

In this passage Babbage shows his perception of the truth that, while certain known causes may undoubtedly operate in a certain direction, the question of "how much?" must be answered before it can be decided whether the phenomena can be attributed entirely to them.

Without knowing what Babbage had been doing, Sir John Herschel communicated a similar theory about the rise and fall of isogeotherms in a letter from the Cape, dated February, 1836, and sent to Lyell[1] His opinion appears to have been in most respects that which I have myself formulated, namely, that the Earth's crust[2] rests in a state of approximate hydrostatic equilibrium[3] upon a molten substratum. The law of hydrostatic equilibrium is simply, that the weight of a mass floating in a liquid is equal to the weight of the volume of fluid which it displaces. If the crust of the earth was perfectly flexible this law would be applicable to every vertical prism into which it might be supposed divided; but since it is not perfectly flexible we must consider areas which are large in comparison of its thickness, and then, if material were to be denuded off one area, it would rise, because it was lightened, while the area to which the material was transferred would sink, because it was weighted. All the while the effective level of the liquid substratum would not be altered by the mere transfer of material. If the thickness of the crust is only twenty miles, or thereabouts, such an area as the delta of a large river would probably admit of the adjustment taking place: much more might we expect this to occur were the area comparable to that of a continent, or to the seaward extension of the detritus from one.

This being premised, let us now endeavour to find answers to the two following questions of "how much?"—(1) what thickness of deposit under certain conditions could be accumulated in a sea of a given depth? and (2) to what height above the sea-level could the deposit be subsequently elevated owing to the access of heat from beneath?

Let us then imagine a continent bordered by a not very deep sea, and that the deposition of sediment has not yet commenced. The isogeotherms under both areas would then be sensibly stationary, and the flow of heat steady under both areas. Next suppose denudation to commence over the continental area, and that sediment is deposited on the sea bottom. The land will begin to rise, and the sea bottom to sink. Whether this goes on equably, or by jerks accompanied by earthquakes, does not concern us now. By the law of hydrostatic equilibrium, the thickness of the deposit possible will depend upon the relative densities of the liquid substratum, and of the crust, which is pressed down into it, because a limit will be imposed by the obvious circumstance that the deposit must cease to accumulate, at least as a marine deposit, as soon as it reaches the top of the water. After this has happened, the detrital matter will be pushed forward beyond the new coast line thus formed, so that on the large scale the entire deposit will have a character of false bedding.

---

[1] Proc. Geol. Soc. vol. ii. pp. 548 and 596.

[2] Physics of the Earth's Crust, chap. x. 2nd edition.

[3] American geologists have called this "Isostacy."

The simple calculations on which the following estimates are based are given in the appended note.

We are obliged to make a guess as to the densities of the crust, and of the liquid substratum on which it floats. I see none more probable than those which I have assumed in my Physics of the Earth's Crust, viz., 2·68 (a fair average for granite) for the crust, and 2·96 (a fair average for basalt) for the substratum. We ought also to know the density of the deposit, which may be put with considerable probability at 2·5, after consolidation. Since the accumulation of the deposit will depress the crust into the substratum, we have to consider whether it is likely that the original crust will maintain its thickness unaltered, or whether some of it will be melted off. It is obvious that on the average the substratum, where it is in contact with the underside of the crust, cannot be able to supply heat to the crust more rapidly than it is carried off by conduction to the surface, otherwise the average crust would be constantly growing thinner, instead of thicker as it must do. Still, if the bottom of the crust was depressed into the substratum, it might be argued that it would reach hotter layers, where it would be melted. But since the heat in a liquid capable of convection cannot become rapidly hotter from the surface downwards, it does not seem probable that much melting would occur from that cause. But on the other hand, the increased thickness arising from the addition of the deposit would retard the flow of heat, and since there is reason to think that the substratum is somewhat above the melting temperature,[1] some thinning of the crust below might arise from this cause. The most probable hypothesis appears to be that, after a sufficient time has elapsed, the action of the substratum will have reduced the new crust, which will consist of the deposit and what remains of the original crust, to the average thickness, that is to the original thickness of the crust at the place in question. But we have in the appended note considered these two cases—firstly that in which none of the crust is melted off, and secondly that in which the thickness of the deposit and old crust together is reduced to that of the original crust. The results are that, in the case of none being melted off, the thickness of the deposit which could accumulate, so as just to reach the surface of the sea, would be 4·26 times the depth of the sea. And in the second case, where the thickness of the deposit and old crust together is reduced by melting off to the original thickness of the crust, the depth of the deposit to fill up the sea would be 10·9 times the depth of the sea. These estimates depend upon the densities assumed; but they do not require a knowledge of the thickness of the original crust.

---

[1] See the Author's Physics of the Earth's Crust, ch. vi. Prof. Bartoli found the temperature of lava issuing from an underground gallery at Etna, in 1893, to be 1060° C., and after flowing a mile it was 870° C., and still liquid. This shows that it was above the melting temperature at its first appearing.

We have next to consider the rise of the isogeotherms produced by the covering, or "blanketing" as it has been called, of the crust by the new deposit, and to estimate the resulting expansion of both. This is the important question started by Babbage, but, so far as I am aware, no estimate has been attempted to be made on the hypothesis of a liquid substratum. In passing it may be remarked that the ascertained fact, that the crust has sunk while being loaded, is a very strong argument for the presence of a liquid substratum.[1]

It is clear that a temperature, perhaps rather above that of fusion, would be maintained beneath the bottom of the crust, and that heat would flow upwards out of the old crust into the fresh deposit; and also out of the substratum into the old crust. Meanwhile the temperature at the top of the deposit would always be that of the sea-bottom, which we may consider to be zero; and the temperature of the bottom of the crust may be taken to be the melting temperature. We shall be sufficiently near the truth if we consider the crust, when under normal conditions, to show a regular increase of temperature with the depth, say one degree F. for 51 feet of descent; and if the deposition of sediment was to cease, an equable rate of increase would after a long time be re-established in the area under consideration, though perhaps with a lower gradient than the normal one on account of a possible increase of thickness of the crust; and the longer the time, the more exactly would this equable rate be attained. Suppose then, for the sake of argument, that the flow of heat was to be held in abeyance until the sea was filled up. The surface of the water being reached, it is clear that no further marine deposit could take place. As soon as this is accomplished, suppose the heat to be free to flow again. Then after the lapse of a long interval the flow will again become steady, and the gradient become an equable one, but until this is accomplished more heat will enter from below than escapes at the surface; so that the mean temperature of the whole column will be raised, and it will expand. This expansion, however, will not alter its weight, so that it will continue to float with its base still immersed at the same depth in the substratum as before expansion began. The head of the column would consequently rise above the sea-level, and contribute its share towards the formation of an elevated plateau. It is obvious that the supposition we have made that the flow of heat is held in abeyance will give the height of the plateau too great, because the column will really begin to swell upwards immediately that the blanketing by the deposit commences, and the sea-level will be reached, and deposition cease, sooner in nature than in the case supposed, because what would actually happen would be, that when the deposit had attained such a thickness that the expansion going on during its deposition had brought it up to the top of the water, then no more could be deposited, and it would be only the balance of heat due after that, to make the flow steady and the gradient equable, which would be actually efficient to raise a plateau. In fact, if the rate of deposition were sufficiently slow, it is conceivable that no plateau at all might be formed, the sea being just filled up by the expanded column. It seems therefore probable that coarse deposits, which are more rapidly accumulated, might be raised into higher plateaus than finer ones.

---

[1] Astronomers admit this. Professor Newcomb says "We have next to consider the effect of viscosity of the earth. Those geologists who have given special attention to the subject regard it as well established that the earth yields under the weight of deposits as if it were a thin crust floating upon a liquid interior and therefore must be a viscous solid if a solid at all."—Monthly Notices of the Roy. Ast. Soc., March, 1892.

Prof. Harkness of the U.S.A. Navy writes of the plausibility of the theory of hydrostatic equilibrium of the crust in his great work on the Solar Parallax, etc.

To obtain the alteration in volume due to the expansion, we require to know the melting point of the substratum, and also the coefficient of expansion of rock. Dr. Carl Barus found the melting temperature of Diabase to be about 1100° C. or 2012° F.; while Professors Rücker and Roberts-Austen have determined that of the Basalt of Rowley Regis to be about 920° C. or 1688° F.[1] We shall not be very far wrong therefore if we put the temperature of the substratum at 2000° F. The coefficient of the expansion of rock has been investigated by several experimenters, and for the voluminal expansion may be taken as 0·0000215 for 1° Fahr.

In the appended note a simple expression is found for the voluminal expansion of the column, consisting of the new deposit and the old crust, after the flow of heat has become steady and the gradient again equable. In the first case examined, when there is no melting off at the bottom of the old crust, the expansion would be 0·09 of the original depth of the sea. Thus, if the sea were a mile deep, the expansion of the column would be 475 feet.

In the second case, where the thickness of the deposit and what remains unmelted of the original crust is supposed equal to the original thickness of the crust (which seems probable), the expansion has been found in terms of that thickness and the depth of the sea. Thus, if the crust were twenty miles thick, and the original depth of the sea were one mile, the expansion of the column after the sea was filled up would be 1800 feet.

The amounts of expansion obtained here are voluminal. And considering that lateral expansion would be prevented by the adjacent parts, it seems proper, as we have done, to assign the whole to vertical elevation. Whether this was accompanied by crumpling or not would not affect the amount of elevation; but, seeing that the horizontal expansion at any given depth would be only one-third of the voluminal expansion at that depth, there could be but very little crumpling at any given place in the rocks, and there seems no means by which the crumpling could be localized.

---

[1] See "Appendix to Physics of the Earth's Crust," p. 19.

Our estimates, as already explained, have been made on the hypothesis that the expansion of the column does not commence until the sea has been filled up, instead of the two processes going on together, as in nature they would do; so that the rising sea-bottom would meet the falling sediment, and the sea get filled up with a less thickness of deposit, while only the balance of heat still required to make the flow steady, acting upon a less thickness of deposit than we have estimated, could be appealed to for the elevation of the plateau.

A depth of 1000 fathoms is the limit of what Mr. Murray calls the Transitional area of the ocean;[1] all beyond being classed as abysmal. It seems, then, that a mile is an excessive depth for the application of our calculations.

On the whole our results do not appear to be favourable to the theory that elevated plateaus, and still less mountain ranges, can have been produced by the expansion of deposits owing to the consequent rise of isogeotherms, and that we must look in some other direction for the efficient causes of those features. What the writer believes these to be, will be found in chapter xxiii. of his "Physics of the Earth's Crust." To describe them here would expand this paper to an undue length.

NOTE.

FIG. 1.

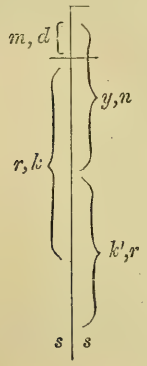
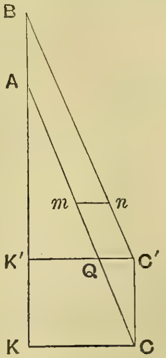


FIG. 2.



---

[1] "On the Height of the Land and Depth of the Ocean," Scottish Geographical Magazine, vol. iv. Jan. 1888.

To find the thickness of deposit which, irrespective of expansion, would raise the sea-bottom by a given amount.

(Fig. 1.)

Let d be the height to which the sea-bottom is raised, k the original thickness of the crust, r its density, s the density of the liquid substratum, m the density of the sea. Let y be the thickness of the deposit, n its density; $k'=k-x$ the thickness to which the original crust is reduced by melting off at the bottom.

Then we have by the conditions of hydrostatical equilibrium,

$$md+rk+s\,(y+k-x-d-k)=ny+r\,(k-x)$$

whence—

$$y=\frac{s-m}{s-n}d+\frac{s-r}{s-n}x. \quad (1)$$

It may be noticed that the original thickness of the crust k does not appear in this expression.

When d is equal to the original depth of the sea, the sea will have been filled up, and the deposition must come to an end at that place. Let us then find the thickness of deposit which would fill up the sea under two conditions.

First suppose there is no melting off. Then $x=0$, and the possible thickness of deposit will be,

$$y=\frac{s-m}{s-n}d. \quad (1)$$

where d is the original depth of the sea.

Secondly, suppose that there is melting off. Then when d and x have both of them attained their greatest values, y will cease to increase. It is evident that the greatest value of d will be the original depth of the sea. We may conclude that, when the deposit and what remains unmelted of the original crust have been reduced by melting to the thickness of the original crust, no further melting will take place; and this will correspond to the greatest value of x. Then we must have,

$$y+k-x=k.$$

$$\text{or } x=y.$$

Substituting y for x,

$$y=\frac{s-m}{s-n}d+\frac{s-r}{s-n}y.$$

$$\text{or } y=\frac{s-m}{r-n}d. \quad (2)$$

which gives the final depth of the deposit, d being here also the original depth of the sea.

We can now make some probable numerical estimates.

Let us take, as explained already, $s=2{\cdot}96$, $r=2{\cdot}68$, $m=1$. For the density of the deposit we may fairly assume $n=2{\cdot}5$. With these values, if none of the crust is melted off, since $\frac{s-m}{s-n}=4{\cdot}26$, the greatest thickness of deposit will be 4·26 times the depth of the sea.

If we make the second supposition, that the deposit and the unmelted crust maintain the original thickness of the crust, since $\frac{s-m}{r-n}=10{\cdot}9$, it appears that the greatest thickness of deposit will be 10·9 times the original depth of the sea. These estimates are necessarily affected by the uncertainty which attends the knowledge of the relative densities. If, for instance, the densities of the crust and substratum are more nearly equal than we have assumed them to be, the possible thickness of deposit in this latter case would be greater.

To find the rise of temperature in the column of the crust and the deposit, and the resulting voluminal expansion.

(Fig. 2.)

Let $AK=k$ be the original thickness of the crust, $AB=y$ the thickness of the deposit and let KC represent the melting temperature t at the bottom of the crust. Then AC will be the temperature gradient at first.

After the deposit has been laid down, and sufficient time elapsed for the flow to have again become steady, suppose $KK'=k-k'$ to be the thickness which has been melted off the bottom of the crust. Draw $K'C'=KC'=t$ and then BC' will be the final temperature gradient.

If we draw lines as $m\ n$ parallel to $K'C'$ these will represent the increase of temperature at each depth, and the elementary area, representing the product of any such line with the increment of depth, will represent the product of the increase of temperature into the increment of volume of the column of unit sectional area; and this, multiplied by the coefficient of voluminal expansion E, will give the expansion of that element of the column. Hence $E\times$ the sum of such elementary areas will give the expansion of the whole column: that is

$$
\begin{aligned}
\text{Expansion of the column} &= E\times\text{area } B\,A\,Q\,C \\
&= E(B\,K'\,C'-A\,K'\,Q) \\
&= E(\tfrac{1}{2}B\,K'\times K'\,C'-\tfrac{1}{2}A\,K'\times K'\,Q) \\
&= E\left(\tfrac{1}{2}(y+k')\,t-\tfrac{1}{2}k'\frac{k'}{k}\,t\right) \\
&= E\left(y+k'-\frac{k'^2}{k}\right)\frac{t}{2}. \qquad (3)
\end{aligned}
$$

If we suppose that there is no melting off at the bottom of the crust, then k' and k are equal, and the expansion becomes $E\,y\,\frac{t}{2}$.

Taking $E=0{\cdot}0000215$, $y=4{\cdot}\,26d$, and $t=2000°$ F., we obtain for the expansion of the column $0{\cdot}09\,d$; so that, if the sea was a mile deep, the expansion of the column subsequently to the sea being filled up would be 475 feet.

If we make the supposition that the thickness of the crust which remains unmelted together with the deposit are equal to the original thickness of the crust, then

$$y+k'=k.$$

$$\text{or } k'=k-y.$$

Substituting this for k' in the expression for the expansion we obtain

$$\text{Expansion} = E\left(yt - \frac{y^2}{k}\,\frac{t}{2}\right)$$

Under the now supposed circumstances we have seen that $y=10{\cdot}9\,d$. If then we take the crust to have been originally 20 miles thick, this gives

$$\text{Expansion} = E\left(10{\cdot}9\,d \times 2000 - \frac{(10{\cdot}9\,d)^2}{20}1000\right).$$

Hence if the sea was a mile deep at first,

$$\text{Expansion} = 0{\cdot}0000215 \times 15860 \text{ feet,}$$
$$= 1800 \text{ feet.}$$

It can be shown by substituting for y and k' in (3), and differentiating with respect to x, which measures the melting off, that the greatest expansion will take place when

$$x = \tfrac{1}{2}\left(\frac{s-n}{s-r}+1\right)k,$$
$$= 0{\cdot}8\,k.$$

This is a greater amount of melting than is probable.

VI.—NOTES ON THE DEVONIAN FISHES OF CAMPBELLTOWN AND SCAUMENAC BAY IN CANADA,—No. 3.

By R. H. TRAQUAIR, M.D., F.R.S., F.G.S.

FISHES FROM THE UPPER DEVONIAN OF DALHOUSIE, SCAUMENAC BAY.

CTENODONTIDÆ.

Scaumenacia curta (Whiteaves).

Phaneropleuron curtum, Whiteaves, Canad. Nat. n.s. vol. x. p. 21, also in Trans. Roy. Soc. Canada, vol. iv. sect. iv. p. 108, fig. 2, and vol. vi. sect. iv. p. 91, pl. v. fig. 3. A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. ii. p. 248.

MR. WHITEAVES in his description of this species mentions that "in one specimen there are indications of what looks like a short break or separation between the anterior and posterior portions of the dorsal (or between the two dorsals if there were two, which is scarcely probable), but this break may be owing to an accidental and abnormal fracture of the fin rays at this point, for in other specimens the two portions appear to be continuous." This break is, however, represented in all his figures, including the restored sketch given in his second paper in the Transactions of the Royal Society of Canada.

But on looking carefully through the whole of the extensive series of this species collected by Mr. Jex last summer and also on re-examining the specimens already in the Museum, I find that there is no doubt whatever, that in all of them the dorsal fin is in two distinct portions, which are separated from each other by a very perceptible interval.

The anterior dorsal commences far forwards; it is low and fringing in character and the length of its base is contained two-and-a-half times in that of the posterior dorsal, the interval between the two fins being equal to one-third of the length of the base of the anterior. The base of the second dorsal extends to a point a little beyond the commencement of the lower lobe of the caudal, but as its rays are long, and the posterior ones directed nearly horizontally backwards, the fin seems to extend near to the tip of the tail. It does not, however, form a continuous dorso-caudal as in *Phaneropleuron,* as hitherto described, or in *Ceratodus* or *Uronemus,* and Mr. Whiteaves is certainly in error in making it do so in his restored figure already referred to. As regards the caudal fin it is in reality *heterocercal,* the upper lobe being represented only by very short rays towards the tip of the body prolongation, while on the ventral aspect the lower lobe is of the triangular form characteristic of Dipterus. Indeed, the resemblance of the fins to those of *D. macropterus,* Traq., from John O'Groat's, is very remarkable, the most striking difference being the more extended base and fringing form of the anterior dorsal in the species under consideration. *Dipterus Valenciennesii, D. macropterus* and *Scaumenacia curta* form then a complete and most interesting series as regards the configuration of their dorsal fins; in the first both dorsals are short based, in the second the posterior dorsal has a base of considerable length, in the third the anterior dorsal is long based, while the base of the posterior one is still longer than in the second.

The question here arises,—what is the condition of the dorsal fin-arrangement in the typical *Phaneropleuron Andersoni,* Huxley?—for on that depends the validity of the new genus which I propose, provisionally at least, to institute for the reception of Whiteaves's *Ph. curtum.* In the Dura Den fish the dorsal fin was originally described by Huxley, and afterwards by myself, as continuous anteriorly, and if that description holds good *Ph. Andersoni* occupies the fourth place[1] in the series of dorsal fin differentiations, and the Canadian species is also generically distinct. The specimens of *Ph. Andersoni* in Edinburgh or even in the splendid collection of Dura Den fishes at St. Andrew's are not sufficiently perfect in the region to afford a decided answer, and I regret that since this question came under my notice, I have not had the opportunity of re-examining those in the London collections, though here it must be noted that Mr. Smith Woodward, in his catalogue of the Fossil Fishes in the British Museum, pt. ii., p. 247, states that the dorsal fin of *Phaneropleuron* is "single," and it certainly appears to be so represented in Huxley's figure of the finest specimen of *Ph. Andersoni* in that Museum. I feel therefore justified in provisionally erecting the

---

[1] As a matter of evolution the series would of course be reversed, *Phaneropleuron* being first and *Dipterus Valenciennesii* last.

Canadian species *curtum* of Whiteaves into a new genus characterised by its double dorsal fin, and for which the name *Scaumenacia* may be proposed.

Mr. Smith Woodward has recently pointed out[1] that in curt the proximal interspinous elements (axonosts) of the anal fin are as in the second dorsal of *Eusthenopteron* and *Tristichopterus* fused into one piece which is followed by three distal elements (baseosts). This is well shown in the present series of specimens, but in one splendid example, wanting the head it is true, but which originally must have been over two feet in length, it is also shown that a third and additional set of ossicular fin-supports followed on the second, though they are ordinarily concealed by the bases of the fin-rays.

Classification.—Although the Dipnoan affinities of *Phaneropleuron* were certainly indicated by Huxley in his "Essay on the classification of the Devonian Fishes," he placed the genus among the Crossopterygii in a distinct family of "Phaneropleurini" which he thus defined:—

"Dorsal fin single, very long, not sub-divided, supported by many interspinous bones, scales thin cycloidal, teeth conical; ventral fins very long, acutely lobate."

To this family I afterwards added the Carboniferous *Uronemus*, but the cranial structure and dentition of both genera were then very imperfectly known.

Cope was, I believe, the first who boldly relegated *Phaneropleuron* to the Dipnoi; but the thing was beyond all doubt when Whiteaves showed that his *Phaneropleuron curtum* was possessed of a ctenodont dentition and an arrangement of cranial plates resembling that in *Dipterus*. That the same points hold good for *Phaneropleuron Andersoni* there cannot be any doubt, and as for the conical marginal teeth, described by Huxley, I have satisfied myself that they are merely the outer denticles of ctenodont plates. Whiteaves's statement that in *Scaumenacia curta* "both the upper and under jaw are armed with smooth conical and somewhat compressed teeth" I have never been able to confirm—at least if "marginal teeth" are hereby meant. Consequently, putting aside the older but less suitable name of Ctenododipterini (Pander and Huxley), I proposed the family term Ctenodontidæ for *Phaneropleuron*, *Ctenodus*, and *Dipterus*, but not for *Uronemus*.

For I had already in 1882 shown that the dentition of *Ganopristodus splendens*, Traq., which I afterwards merged in *Uronemus*, was NOT *ctenodont*; but that on the other hand the anterior part of the palatopterygoid bone, broad and flat, is covered merely by small rounded tubercles, while along the outer margin is one row of laterally compressed, basally confluent, short conical teeth.[2] Such an important difference in dentition seemed to me in 1890 amply to justify the separation of *Uronemus* from *Phaneropleuron* and its allies in a distinct family of Uronemidæ.[3]

---

[1] Ann and Mag. Nat. Hist. (6) vol. xi. p. 241.

[2] Geol. Mag. (2) Vol. IX. p. 543.

[3] Proc. Roy. Soc. Edin. vol. xvii. p. 393.

Mr. Smith Woodward, however, in the second part of his Catalogue of the Fossil Fishes in the British Museum, retains the family of Phaneropleuridæ, in which he also still includes *Uronemus*. That *Uronemus* must, on account of its non-ctenodont dentition, be placed in a different family from *Phaneropleuron* is, as I have above stated, perfectly clear to my mind at least; for the rest, the Phaneropleuridæ are separated from the Ctenodontidæ, according to Mr. Woodward's definition, by the possession of marginal teeth and of jugular plates. As regards the former character I believe it to be founded on a mistaken interpretation; as to the latter, are we quite sure that we know the structure of *Ctenodus* sufficiently well to be able to decide with certainty as to whether it had jugular plates or not?

Mr. Woodward also erects a separate family for *Dipterus*—that of the Dipteridæ, the essential characters of which, as distinguished from those of the Phaneropleuridæ, are: the absence of marginal teeth, and the heterocercal configuration of the tail, this form of caudal fin along with the possession of jugular plates distinguishing it from the Ctenodontidæ. It is not necessary to repeat what has been said as to the marginal tooth question; as regards the heterocercal tail in opposition to the diphycercal form, if we accepted that as a family character in the Crossopterygian fishes we should separate genera which otherwise are most closely allied. Take the Rhizodontidæ for example,—in *Rhizodopsis* the tail is heterocercal, in *Gyroptychius* as nearly as possible diphycercal; so in like manner the most marked distinction between *Tristichopterus* and *Eusthenopteron* is the decided heterocercy of the former and the nearly perfect diphycercy of the latter. But the median fin-system of *Scaumenacia* is connected by so perfect a transition through *Dipterus macropterus* to that of the typical *D. Valenciennesii*, that I cannot see how it can be placed in a different family on characters based on those organs.

Consequently I must for the present still consider it the safest thing to include *Phaneropleuron, Scaumenacia, Dipterus, Ctenodus* and their immediate allies in one comprehensive family of Ctenodontidæ, characterised by the possession of numerous dermal cranial roof-plates and a ctenodont dentition.

COCCOSTEIDÆ.

Coccosteus Canadensis, A. S. Woodward, GEOL. MAG. (3), Vol. IX. (1892), p. 483.

One plate referable to *Coccosteus* and presumably to the above-named species occurs in the present collection. It is the posterior ventro-lateral of the left side, and is peculiar in being narrow posteriorly, and in having the stellate based tubercles with which it is ornamented much coarser than in the typical *C. decipiens* of the Scottish Old Red.

HOLOPTYCHIIDÆ.

Glyptolepis Quebecensis, Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 77, pl. v. fig. 4. A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. ii. p. 336.

The specimen here referred to is the head and anterior part of the body of a large *Glyptolepis*, the only example of the genus in the present consignment of Canadian fishes. It measures nine inches in length, of which five are occupied by the head. The mandible measures four inches in length; small conical teeth are seen along the dentary margin but the large laniaries are covered up. The free surface of the scales is ornamented with very fine, close, wavy ridges, sometimes irregular or contorted, but mostly longitudinal and tending to converge posteriorily, while they are also often branching and interrupted. In front of the striated portion there is a narrow, semicircular, or crescentic area of small tubercles. The scale-ornament is more delicate than in the Scottish *G. paucidens* and *G. leptopterus*, to which the fish is evidently closely allied.

Here again specific identification is a matter of conjecture, as there are no marks by which it can be positively identified with the small fish described by Whiteaves as *G. Quebecensis*, seeing that it shows neither fins nor configuration of the body, on which characters Mr. Whiteaves's diagnosis was principally founded, while his specimen, on the other hand, did not display the ornamentation of the scales or cranial bones. Mr. Whiteaves mentions, however, the occurrence of two large scales, showing a sculpture resembling that of the scales of *G. leptopterus*, and which he thinks may indicate a second species; he also states that, "it is however possible that they may have belonged to large and adult examples of *G. Quebecensis*, and that the specimen upon which that species is based may be a very immature individual." I accept the latter alternative in the meanwhile, rather than name a new species without sufficient warrant.

RHIZODONTIDÆ.

Eusthenopteron Foordi, Whiteaves.

Eusthenopteron Foordi, Whiteaves, Canadian Nat. n.s. vol. x. 1881 p. 31. Trans. Roy. Soc. Canada, vol. vi. sect. iv 1889, p. 79, pl. v. fig. 5; pls. vi. vii R. H. Traquair, GEOL. MAG. (3) vol. vii. 1890, p. 17. A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. 2, 1891, p. 362.

The present series of specimens shows the large size attained by this fish, two nearly entire examples measuring respectivly 23 and 24 inches in length, and each would be at least an inch longer were the extreme point of the tail preserved.

Two points I wish to bring forward on the present occasion.

The first is the presence of a small pineal foramen on the top of the skull between the frontal bones, in the very same position as in the Osteolepid genera *Diplopterus Thursius* and *Osteolepis* in which it has been so long known to exist.

The second is the palatal dentition. There is one large palato-pterygoid bone similar to that which I figured nearly twenty years ago in *Tristichopterus*,[1] and which extends from the vomerine region in front to the articulation of the lower jaw behind. Along the anterior two-thirds of the outer margin is articulated, a row of three ossicles bearing the upper laniary teeth, and thus corresponding to the mandibular internal dentary ossicles on which I long ago showed that the laniaries of the lower jaw (except the anterior one) were borne in *Rhizodus.* There are two vomers placed behind the premaxillæ, each of which, as in the Osteolepidæ, bears a large laniary tusk. As in the Holoptychiidæ, Rhizodontidæ, and Osteolepidæ in general, the maxilla proper bears only very small teeth.

---

[1] Trans. Roy. Soc. Edin. vol. xxvii. pl. fig. 3.

VII.—The Shell-beds of Moel Tryfaen.

By Prof. J. F. Blake, M.A., F.G.S.

THE idea that the well-known shell-bearing sands of Moel Tryfaen indicate a submergence to the depth at which they are found, cannot perhaps be yet said to be, in the language of Mr. Dugald Bell, "a day-dream of the past," though it is fast becoming so. Towards this result there must be two stages—disbelief in the submergence, and belief in something else. As to the first, Sir A. Ramsay wrote—"He must be a bold man who could see the shell-beds at Moel Tryfaen and deny that the sea had been there." I remember quoting this to my much lamented friend Prof. Carvill Lewis and receiving for reply, "one has to be bold sometimes if one would come at the truth." For my own part the result of seeing them for the first time would be expressed in Sir A. Ramsay's words with one alteration only—the substitution of "affirm" for "deny," so that with me the first step was soon taken. The second step is somewhat more difficult if we want to get a clear idea of the method of the transport of the shells, and being recently at the spot, on other business, I thought it might be well to note some of the details which must guide us to a right explanation, but which do not appear to have been as yet very particularly noted.

In the first place the supposed difficulty of getting the "Irish Sea glacier" to so great a height is not one which would have troubled Sir A. Ramsay, nor any one else who knew the district; it is a mere question of a couple of hundred feet, for if ever there was a glacial moraine where no ice is now, it is on the west side of Moel Tryfaen. Indeed there are several. Coming up from the level of the Gwyrfai River, we pass over three well-marked long mounds, the highest one having the steepest slope and looking from the lower ground like a long range of hills. These all run parallel from about N.NE. to S.SW. and they are all composed of the most typical moraine stuff and crowded with huge stones of which many are granite absolutely unknown in Wales, and other rocks which must have come across the sea, with occasional masses of Carboniferous rocks, limestone, and sandstone, only derivable from Penmon, a thousand feet below their present level. That such mounds as these could be the droppings of icebergs never did and never could enter the head of Sir A. Ramsay, who recognized them as certain proofs of a huge glacier or ice-sheet that had crossed the Irish Sea and of which they were the terminal (or perhaps the lateral) moraines. Now the summit of the highest of these long ridges is 1100 feet above sea-level. If the glacier could rise as high as this, it would be a small matter to rise a little more. It was only the presence of the sea shells which led to the belief that after the glacier had disappeared, the land had been submerged, not locally, so as to reduce the relative level of these moraines, but over the whole of Wales.

But now comes the real difficulty. The shell drift is on the other side of Moel Tryfaen and the moraines have no direct connection with it. The uppermost and best defined of these stretches in a continuous mound from Braich Melyn Smythaw by Moel Tryfaen village to the slate railway incline. To the E.SE. of this is the high ground of Moel Tryfaen and Moel Smythaw, both of which, on their western slopes, on their summits, and on part of their eastern slopes, are entirely free from drift; and there is only about a quarter of a mile between exposures of live rock on either side of the pass between the two through which the drift could be carried, and this path is at right angles to the trend of the moraine. It is difficult to say whether these hills have ever been glaciated. The temptation to think so is afforded by the great projecting masses of conglomerate which so characteristically cap the summit of Moel Tryfaen, the rest of the hill being of a more generally rounded form. This is so like what we may imagine to be the phenomenon of a *nunatak* that it is hard to resist the idea of its being such. Still we may easily account for it otherwise; for the hardness of the conglomerate resting on softer rocks would be an adequate cause, as in the case of the Brimham rocks of Yorkshire. I am not aware that glacial striæ have ever been found on the upper parts of these hills. There are numerous unrounded crags about on the surface, and the rocks on Moel Tryfaen—where there is a good variety—lie on the surface so accurately in order (now that that order is known) that they must have weathered *in situ* and not have been moved since. So that if ever the ice were there it must have been so long ago that all signs of it have been obliterated and the signs of ordinary weathering have taken their place.

These two hills form part of a long boundary which separates two very distinct glacial areas. Moel-y-Ci, Rhiwwen, Clegyr, Cefn Dui, Moel Smythaw, Moel Tryfaen and Mynydd-Cilgwyn, from a range, on the west of which we find moraine-like heaps with foreign boulders, while on the east the boulders (as far as I have been able to discover, and with the exception of Moel Tryfaen deposits) are not of foreign origin, and the drift is not spread out in the form of moraines. I take it that these hills stood like outposts to the North Wales camp in glacial times and forbad the invader to overstep their lines.

The nature of the problem to be solved must now become evident. How is it that these shelly deposits have found their way within the North Wales line? Why do we find within this area a deposit which, though not of a moraine-like form, does contain foreign material including shells? And how is it that such deposits are at over 200 feet higher level than the highest of the moraines? For the solution we naturally look to the details of the deposits. These are at present beautifully shewn in the Alexandra quarries, which are being enlarged and the bearing cleared. From 30–40 feet of Glacial beds are exposed, lying on the irregular surface of the slates, in which there is very little, if any real, terminal curvature. These beds die out and disappear on the slope of the mountain to the west. They equally die out to the south, as seen in the Moel Tryfaen quarry. Towards the east they are not exposed, but the upper part of more clayey drift is thickening in that direction, and probably replaces the shelly. One or other of them is spread out in a fan-shaped mound, forming a feature in the upland valley, and leading on to Hafod-y-wern slate quarries in the Bettws Garmon valley, where perhaps 60 feet of drift with small foreign pebbles is seen sloping down towards the locally glaciated valley. On the eastern margin of this mound there is a great felsite erratic.

In the Alexandra quarries the difference between the shell-bearing sands and the overlying Boulder-clay is well marked, the latter lying in hollows, or in festoons in the former. The Boulder contents of the two do not appear to me to be very different; in both the stones which may be, and probably are, of Welsh origin, are the largest—in the shelly-drifts they are immense—and in both there are smaller (3–4 inch) rounded stones of foreign granite—Criffell, etc. Under these circumstances it does not seem necessary to trouble about the overlying beds; anything special they contain can be easily derived from the shelly-drifts below.

Such are the data we have to go upon, in addition to the well-known characters of the sands and shells. Now when a submergence was assumed as the cause, the foreign pebbles that occur amongst the sand necessitated that the date of that submergence should be after the arrival of the ice-sheet, but if the sands were brought by the ice-sheet itself, they would be the first to come. Starting from the mountains of Scotland, or the Lakes, it would be the *front* of the ice that would first reach the sea, clear it of its loose shells, and carry them forward to Wales. We may therefore safely say that the shell-drifts of Moel Tryfaen are the very earliest of the glacial deposits, other than local, in North Wales, and the shells themselves must have lived in pre-Glacial times. This is quite consonant with the occurrence of the small rounded granite, etc., pebbles in these drifts; they are some of the pebbles of the old Irish Sea, and have suffered little injury at the hands of the ice-sheet. A terminal moraine is the sign of a retreating glacier, hence the long mounds on the west of Moel Tryfaen are the products, not of the advance but of the decadence of ice-sheet; the materials which should be contemporaneous with the shell-drift have been carried away south, and it is just because these shell-drifts have found a corner to rest in, out of the main route, that they have been preserved.

How then did the material get separated from the rest of the moving mass? We might imagine that the sheet came pressing against the northern flanks of Moel Tryfaen, and split in two, leaving the lateral moraine stuff on the eastern side. In this case we should expect to find many angular masses of the conglomerate amongst the *debris*, and that the resisting front of the mountain should be greatly glaciated, neither of which is the case. If this be not the history, then the ice must have come either over Moel Smythaw, or along the pass between it and Moel Tryfaen. That it came, in part at least, over Moel Smythaw is evidenced, I think, by the great erratic of felsite mentioned above; but our main guide must be the immense boulders of probably Welsh rocks which occur in the sands, together with the still more curious fact of the foreign pebbles in the drift overlooking the Bettws Garmon valley. Both these things point to a commingling of the two moving masses—the Irish Sea glacier and the Welsh Bettws Garmon glacier. They would meet nearly at right angles. This, from the analogy of rivers, we should expect to produce a kind of back-wash, the front of the Bettws Garmon glacier, and the side of the great glacier, would be squeezed out together into the angle between the two. The pressure thus produced would raise this isolated mass of ice to a higher level than either, and force it into a place of rest on the east side of Moel Tryfaen. Here it would ultimately melt, and the contained *debris* would wash down the slopes where now we see them. In this way the great local boulders have been carried all round Moel Smythaw in more than a semicircle, and a similar course has been followed by the small foreign stones on the side of Bettws Garmon. In this way also any riebeckite rock found on Moel Tryfaen may have come round from Mynydd Mawr.

There are, however, to the north of this spot several other valleys, as Nant Francon and Llanberis, which should have produced analogous results. Doubtless they did so, but when we examine the area where the back-wash of these should lie, we find it is open country, where they would not be allowed to rest. It is only in the case of Moel Tryfaen that there is a nice little quiet corner, where they could be undisturbed if once they were introduced, and this fully accounts for their being so exceptional.

VIII.—FORAMINIFERAL LIMESTONES FROM THE GRENADINE ISLANDS, WEST INDIES.

By A. J. JUKES-BROWNE, B.A., F.G.S.

THE specimens which form the subject of this note were sent to me by Mr. G. F. Franks, F.G.S., of Bridgetown, Barbados, and were obtained by a correspondent of his from the island of Canouan, one of the Grenadine group. Mr. Franks had made slides from three of the samples, and having recognised them as foraminiferal limestones he sent them to me for fuller examination, stating at the same time that the limestone was associated with a compact igneous rock, apparently a porphyritic andesite, with abundant glassy ground mass enclosing streams of microliths. He also sent fragments of four different varieties of the limestone, and my friend Mr. W. Hill has been kind enough to cut me a slide from one of these which appeared different from the others.

Two of the specimens are of a light but dull red colour, hard, crystalline and traversed by thin veins of calcite. Slides cut from these two and examined with a one-inch objective showed them to have practically the same structure. They consist of a calcified ground mass of fine material, full of rounded bodies which can be identified as *Globigerinæ*. All are much altered and are filled with calcite, but in many of them the cell walls can be clearly distinguished; others are so blurred and calcified that unless some were better preserved they would hardly be recognisable. There are also many smaller blebs of calcite which may represent the single spheroidal cells so often found in Chalk and in Globigerina ooze. No other mineral but calcite is discernable, and the rock may be regarded as a fine-grained Globigerina ooze which has undergone partial marmarosis.

A third specimen is a compact and crystalline grey limestone, in which many minute specks of iron-pyrites can be distinguished with the unaided eye. Under the microscope it is seen to contain a much greater variety of ingredients than the limestone above described. *Globigerinæ* are very numerous and in a better state of preservation, the cell-walls being quite clear and distinct, but with them are some larger Foraminifera, chiefly *Amphisteginæ*, and a few which appear to be small *Nummulites*, and one or two nautiloid forms. There are also many fragments of a clear yellowish mineral which appears to be glauconite; but differs somewhat from the green glauconite of our own Cretaceous rocks. The grains are of irregular and often angular shapes and some of them seem to be entangled with crystals of calcite; such grains polarize in patches which change from yellow to dark-grey, while parts remain clear and yellow, as if the original mineral had undergone some partial kind of alteration. As, however, the same yellowish mineral is seen filling some of the *Globigerinæ*, I think it may be regarded as glauconite, and Mr. J. J. H. Teall, F.R.S., to whom a slide was submitted, concurs in this opinion.

Scattered through the slide are many very small cubical crystals of an opaque mineral, which is evidently the iron-pyrites visible in a hand-specimen.

The fourth sample is also a compact crystalline grey limestone, similar in general aspect, but without any pyrites. Under the microscope further differences are apparent; there are no *Globigerinæ*, the rock being chiefly made up of *Amphisteginæ* and *Nummulites*,[1] with a few others which resemble Cristellaria in section and some fragments of shell. Mingled with them are grains and patches of a yellowish glauconitic mineral occurring in the same way as in the specimen just described. There seems to have been a little greyish mud between the Foraminifera, but it does not occupy so much of the field as the latter do, and the interstices are filled up with crystalline calcite.

The interest of these limestones is (1) their occurrence in the Grenadine group, which was supposed to consist entirely of igneous rocks, and (2) their similarity to rocks which occur in Trinidad and Barbados. Barbados lies about 120 miles to the E.NE. of Canouan, and San Fernando, in Trinidad, is about 170 miles away to the southward.

---

[1] For the identification of these genera in the slide, I am indebted to Dr. G. J. Hinde, F.G.S.

The Globigerina Limestone might be an indurated chalk of Barbadian type, but it can also be compared with the Globigerina marls recently described by Mr. Lechmere Guppy,[1] and its association with a rock containing shallow-water forms, such as *Amphistegina* and *Nummulites* is a fact which specially recalls the San Fernando section, where a certain band of limestone is said to consist chiefly of *Amphistegina* and *Nummulites, Rotularia clymenioides* and Nullipores.[2]

The San Fernando beds are considered to be of Eocene age by Mr. Guppy, and if Eocene is used in its older Lyellian sense as including all that is older than Miocene, he may be right; but the classification of the Tertiary deposits of the West Indies is at present in a very unsatisfactory state. It is at any rate interesting to find in this small patch of limestone on Canouan what seems to be evidence of the northerly extension of the sea in which the Foraminiferal deposits of Trinidad were accumulated.

IX.—NOTE ON THE TUSCAN ARCHIPELAGO.

By C. S. DU RICHE PRELLER, M.A., Ph.D., M.I.E.E., A.M.I.C.E., F.C.S., F.G.S.

IN the course of a recent prolonged residence in Tuscany and the Carrara Marble District, I had occasion to become well-acquainted with the Maremma hills and the islands composing the Tuscan Archipelago; and as I propose to revisit those islands at an early date with a view to more closely examine certain phenomena relating to the eruptive and metamorphic series more especially of Elba, it may not be out of place if, in the meantime, I give a rapid preliminary sketch of the leading geological and petrological features of that archipelago as a whole.

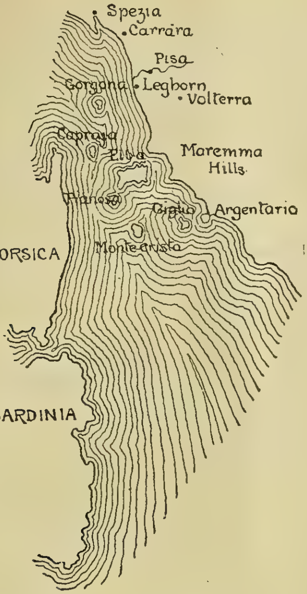
As is well-known, the exceedingly interesting but also extremely complex phenomena which are met with more especially in Elba have, apart from the mineral wealth of that island, for many years attracted the attention not only of Italian, but also of other geologists such as Vom Rath, Rayer, Dalmer, Nessig, and others. In not a few cases, however, the more or less cursory inspection on the spot by some, and the one-sided microscopical examination of a few isolated and hence not representative specimens by others, have led to a variety of conflicting and not infrequently erroneous views. The recent survey of the island, made on behalf of the Italian Government by Signor Lotti and his coadjutors, is therefore the more welcome, as at any rate a modern and adequate geological map of that classic locality is now available as a basis and starting-point for further research.

It need hardly be pointed out that the Tuscan Archipelago not only constitutes the connecting link between the mainland of the Italian peninsula and Corsica and Sardinia, but also forms part of the chain of islands which fringe the whole length of the peninsula as far as Sicily, and whose eruptive phenomena in more ancient as well as in recent geological epochs have been both the cause and the effect of great changes no less on the mainland of the peninsula than in the Mediterranean itself.

---

[1] Quart. Journ. Geol. Soc. vol. xlviii. p. 519.

[2] *Op. cit.* p. 523.



The islands composing the Tuscan Archipelago, and situated, roughly speaking, at about thirty miles from each other, are Gorgona, Capraja, Elba, Pianosa, Montecristo, Giglio, and the promontory, practically also an island, of Argentario.

The most ancient rocks of the Tuscan Archipelago are the pre-Silurian schists and serpentines of Gorgona, Giglio, Argentario and the eastern part of Elba, bearing analogy not only with the same series of Sardinia and the north-eastern part of Corsica, but also generally with the Archean and Cambrian series of the Alps. In the eastern part of Elba, these schists and serpentines underlie the Upper Silurian fossiliferous schists, and although Dieulefait refers the Corsican serpentines to Trias, or at all events declines to accord them a greater age than Permian, their analogy with the Elban rocks stamps them as undoubtedly pre-Silurian.

The rocks overlying the Upper Silurian strata in the islands of Giglio, Argentario, and also in the Maremma hills, have been referred to Permian from their analogy with the schists of Monte Pisano, the highest peak of the Carrara mountains where Permian fossils have been found.

Of the secondary formation, Trias is conspicuous by its absence in the whole of the Archipelago, and Infralias, which is also represented in the Maremma hills and in Corsica, rests directly not only on the Permian, but also on the Silurian and pre-Silurian rocks. The Lias series is represented in Elba but not in the other islands, and gives evidence of another remarkable break, inasmuch as it overlies directly the Permian and even the pre-Silurian strata. The Upper Lias comprises the metamorphic rocks, felsitic schists, and compact and crystalline limestone with garnet and Wollastonite, which are met with on the summit of Monte Cappane, the highest point of Elba, where they overlie the granite. Upon the Upper Lias strata follow immediately the Eocene rocks, thus marking another characteristic gap which is also conspicuous in Corsica as well as in the Maremma hills. Indeed in Elba, the Eocene strata rest not only on the Lias, but also direct on the pre-Silurian formation. They comprise in upward series, nummulitic schists, red, green, and grey limestone, followed again by nummulitic limestone, limestone, schists and sandstone, with numerous and extensive dykes of serpentine, gabbro, and diabase. The Eocene serpentine frequently appears in close proximity to the ancient serpentine, from which it is easily distinguished alike by its different texture and location. It is a characteristic feature that the Eocene serpentine, gabbro, and diabase of undoubtedly igneous origin always occur together in the same superposition. The Upper Eocene strata are traversed by great viens of porphyritic granite, and the fact of these strata having been proved to be nummulitic and hence Eocene proves the further important fact that the intrusive Elban granite, which has been so fruitful a source of controversy, is neither trachyte, nor liparite, nor felsitic porphyry as it has been called by some petrologists, but is a true tourmaline-bearing porphyritic granite of Tertiary age. Moreover, the same intrusive granite occurs under analogous conditions in the islands of Montecristo and Giglio, as well as on the mainland in the Maremma hills.

Of the metalliferous deposits of Elba, some are found in the pre-Silurian, others between the Permian and the Liassic, others again between the Permian and Infralias strata, while the workable deposits of oxide of iron and the limestone and siliceous rocks with which they are associated, are younger than the Eocene sedimentary and intrusive rocks already referred to. The Miocene and Pliocene strata are absent in the Archipelago with the exception of Pianosa, where they bear close resemblance to the Corsican rocks of the same age. The post-Tertiary formation is represented in Elba, Giglio, and Pianosa by a coarse calcareous sandstone and a conglomerate with marine-shells, which in part edge the coast and in places reach a depth of over 600 feet above sea level. The andesites of Capraja probably erupted during the same period.

It is thus seen (1) that the islands of the Tuscan Archipelago are, geologically and petrologically, closely connected, not only with each other, but with the Maremma hills on the one hand, and with Corsica and Sardinia, as well as with the Ligurian Alps on the other; (2) that, therefore, they probably constitute part of a former Tyrrhenian continent; and (3) that as a whole, and with a few significant exceptions, they are representative of every geological formation from the pre-Silurian downwards, irrespective of the exceedingly interesting eruptive series, which it is not the purpose of this preliminary notice to discuss.

X.—WAS THE DEPOSIT OF FLINT AND CHALK CONTEMPORANEOUS?

By G. ABBOTT, M.R.C.S.

MANY difficulties remain to be solved and much work to be done before we rest satisfied that we can understand how flint took the peculiar shapes and position in which we find it in the Cretaceous strata.

Most geologists will now agree with me that we must look to the action of segregation for the explanation. The older theory of colloid silica, as well as that of the chemical replacement of the organic matter in the sarcode of sponges by silica, long held sway, and even yet their influence is to be traced in the most recent literature on the subject.

To advance our knowledge and to obtain a working hypothesis at once accurate and comprehensive, ought we not to commence by trying to find out *when* the silica was deposited? Did it take place before or after the Chalk was raised above the sea-level?

Many writers imply, if they do not state, that the formation of flint took place contemporaneously with the deposit of the chalk strata. With this I disagree; anyway it seems of the utmost importance that this point should be inquired into, for manifestly the influences at work to effect the chemical changes would be quite different in the two cases.

The *tabular* flint of the Upper Chalk appears to give us some valuable data with regard to this point.

During the last twelve months I have examined all the specimens I could find, many *in situ*, and they all showed signs of having "grown" in faults.[1] Besides being found in the position where one would expect to find such fissures, they show innumerable traces of having been formed of two plates originally distinct, but which by the gradual addition of silica have approached each other and united into one thick tabular mass. Few specimens fail to show where this junction took place, whilst here and there irregular cavities remain, due, I presume, to the process in that portion being incomplete when segregation ceased.

The thickness of these tabular flints varies considerably—ranging from $\frac{1}{4}''$ to $6''$ or more, sometimes almost reaching these extremes within the space of a foot, but more often lying for long distances between fairly parallel walls. The external surfaces correspond to those of the broken chalk, having here and there excrescences which indicate the growth of flint in cavities on the walls of the fissure, the surfaces in some specimens being so angularly rugged that the Chalk must have been dry and hard when the fissure occurred.

I have looked for, but hitherto have failed to find, any other satisfactory explanation of these remarkable dyke-like deposits.

---

[1] This can hardly apply to the continuous *horizontal* layer of flint which occurs in the Chalk from Thanet to Dover.—EDIT. GEOL. MAG.

If, however, we may use this as a working hypothesis that tabular flints "grew" by gradual accretion and quite independently of any organic agency, can we any longer believe they were formed even partially when the Chalk was beneath the sea. The upper part of the Chalk would then have been in the condition of soft ooze, and even if cracks were formed, the spaces would have been quickly filled with cretaceous matter and the deposit of flint rendered impossible owing to the length of time it would have taken to "grow" on the walls of the cleft.

Very much of course depends on the settlement of this question. Will someone point out if it is unreasonable to look in this direction for a solution of our difficulties in reference to chalk flints?

If any of the old theories or even that of segregation *below sea-level* be applied to special forms of flint—paramoudra for instance—they fail to answer even the most obvious questions. The old idea that these potstones originated in cup sponges has been discredited because of the difficulty of understanding how sponges could grow out of one another and extend in great columns like paramoudra, through the height of the cliff. Unfortunately I have had no chance to examine them *in situ*, and therefore only hesitatingly suggest that their origin was entirely independent of animal organisms, they being merely broken pipes of silica which formed in the chalk subsequent to its elevation above sea-level. The silica might have been supplied by the percolation of water through the overlying arenaceous strata, while each section of the broken pipe after its slight displacement by the movement of the Chalk which led to its fracture, would probably still act as a centre for further deposits of flint, and thus all traces of *fracture* would soon be obliterated.

Both paramoudra and tabular flint I believe to have been caused by the deposit of amorphous and crystalline forms of flint in chalk cavities—each by gradual growth extending in the direction of least resistance, without depending upon the help of organic remains, but enveloping and matting together any substances close at hand.

Careful observation of an immense number of other specimens leads me to suggest that in spite of the bossy, irregular forms assumed by flint, it has increased after the same manner as other concretions. This condition is much obscured by the presence of colloidal silica, and has perhaps not been observed because it was not expected or looked for. Instances, however, can be well seen in the interior of hollow flints with cores, supposed to be the silicified casts of the cloacæ of *Siphoniæ*. Although these cores correspond as a rule to the long axis of the cavity, yet there are frequent exceptions. Smaller secondary cores, too, are often present lying at various angles and blending into each other.

It has long been accepted as a fact that flint has often commenced to form in chalk by means of sponges, many of which were subsequently removed after acting as a sort of scaffolding for the flint. This explains the numerous hollow flints met with. To these organisms we must add many others, such as wood, shells, etc., which have acted as centres for the segregation of flint.

Owing to the fact that the addition of fresh silica often destroys all traces of the growth-stages of a flint, very little information can be obtained when the process is complete and the nodule a mere solid mass of flint. Fortunately there are innumerable cases to be found in every stage of development, and those who care to look can find them in most districts of the S.E. of England where the Upper Chalk exists. The absence of flint in our lower beds[1] would of course be explained by the assumption that only half the beds were above the sea-level when the process of segregation was going on.

I may, in conclusion, reduce my suggestions to the following propositions:—

1st. That Flint in the form now found in the Chalk was deposited subsequent to its upheaval above sea-level.

2nd. That whilst the large quantity of siliceous sponge spicules present must have had a considerable share in the formation of the nodular and perhaps the tabular flints, yet quite as frequently various other hard substances and even empty spaces assisted.

3rd. Chalk flints grew after the manner of crystals [or concretions?] and were regulated by similar laws.

TUNBRIDGE WELLS.

XI.—ANOTHER VIEW OF THE SUBMERGENCE OF THE BRITISH ISLES DURING THE GLACIAL PERIOD.

By JAMES D. HARDY.

I QUITE agree with the *submergence* of the British Isles during the last or any Glacial period; but I totally disagree with the theory that there has been any such *depression of the land* as is generally put forward by geologists. Where is the evidence of such depression? Certainly not since Pliocene times, unless the whole of Great Britain sunk and rose simultaneously like the parallel motion of a beam engine. Such a motion would imply not only a surface movement, but also a sinking of all underlying strata. How such a theory ever held for a time is a puzzle to me, excepting the absolute necessity of finding some reason for the sand and shell deposits up to 1500 feet O.D. That the whole of England and at least the greater part of Scotland was covered with water there is evidence enough, and that Britain was not covered with an Ice-cap there is also evidence, if one will look at it free of all old book theories. Geologists—like other specialists—follow their bell-wethers, first in one direction, then in another, and are rarely able to bring other knowledge to bear on their arguments, as I have found when arguing on this depression theory with them.

---

[1] Mr. David Forbes, F.R.S., pointed out, many years ago, that the Hard Chalk and Grey Chalk really contained an equal quantity of silica as the Upper Chalk with flints, but it had not segregated out into flints in the former as in the latter formation. An excellent account of the Chalk formation and of the Flints and their probable mode of origin will be found in the Geology of England and Wales by Horace B. Woodward, F.G.S. (1887) pp. 397–401. See also paper on Banded Flints by Dr. S. P. Woodward (GEOL. MAG. 1864, pp. 145–149, Plates VII. & VIII.), and the Isle of Thanet and its Continuity of the Flint Floorings by F. A. Bedwell, M.A., F.R.M.S. (GEOL. MAG. 1874, pp. 17–22, and Proc. Geol. Assoc. 1873, vol. iii. pp. 217–238, pl. iv.).—EDIT. GEOL. MAG.

What is the evidence with which we have to deal? Beyond the deposits of shell and sand at 1500 feet O.D. there are the remains of glaciers from the Cumberland Hills and Snowdonia—also the Scotch glaciers; of great boulders removed for some miles from the parent rocks, evidently the work of icebergs. Beyond this there are the great masses of Boulder-clays and Crags on the East coast. The Scotch hills bear evidence of Ice action, but not necessarily an Ice-cap—in fact their scorings on the high levels and the *roches moutonnes* of the Lowlands point to moving ice as the cause. Floe-ice probably of great thickness floating away from the higher hills towards the lower—or following the outlet stream.

Now if we look to the South Polar regions, even at the present time, we have quite sufficient evidence to guide us to a proper appreciation of the condition of Britain during the last Ice-age; we see there an accumulation of ice and snow down to the 55° parallel (at least). This is entirely surrounded by water. What is the probable thickness of the ice at the South Pole? Taking an angle of only half a degree at 50° south will give us twelve miles at the Pole. We have only to read Nansen's "Journey across Greenland" to see that it does not require 40° of latitude to give a thickness of ice and snow sufficient to cover the highest hills of that country, but only 1000 miles, though this ice is the remains to some extent, of the last glacial period. We are thus justified in assuming that at the extreme of the glacial epoch, the ice at the North Pole was of the same depth as at the South Pole at the present time. We also find that the level of the water is maintained equally at the edge of both the northern and southern ice. This is the great factor of my theory respecting the conditions presented over England and Scotland. Transposing the positions, we have an ice-cap reaching as far south as the northern part of Scotland *and the water rising level to it.* If the ice-caps at the Poles were 12 miles thick then the water (at $\frac{1}{2}$° angle) would be 2000 feet deep over the central parts of England. This is the submergence dear to geologists, but no depression of land is required. Icebergs breaking away from the edge of the ice-cap would carry any of the boulders we see, and the floe-ice, as the water decreased in depth as the glacial period was passing away, would cause all the scoring and smoothings everywhere observed. The glaciers and moraines express the last of the ice action after the water had left the land, but while it was still under the influence of a cold period.

As I referred to the southern pole as being now under the influence of an ice-cap, it shows that it is not necessary to bring Dr. Croll's theory of the lengthening out of the orbit to cause a glacial period, as the orbit at the present time is as nearly circular as it can be; but that such is simply due to the proportion of winter days to summer days (166 to 199), and the action of the sun on the ice-sheet during the latter term (*vide* Nansen again).

I now come to the *crux* of this argument, viz., the rise and fall of the water. For some years I have been very much puzzled to account for this. It was evident to me that water covered the land; but where did it come from, and where has it gone? and that so gradually as to lay down our Crags so uniformly—until disturbed by passing ice-sheets; but I have found that it is the nature of the ocean, especially at the Poles, to find its level according to the height of the ice-cap. That some natural law was at work to cause this there can be no doubt, and this is to be found in the *attraction* of the accumulated mass of ice. A continent of ice 5400 miles in diameter, with an average of six miles in thickness above the normal level, must exert a very appreciable amount, especially as this is accumulating at the same time that the ice at the North Pole is losing its attractive power. But we shall have to clear away some of the cobwebs of science—especially astronomical—before men's minds are free and unbiassed enough to approach the consideration of this question from this point of view, so here I must leave it for the present.

REVIEWS.

THE GEOLOGY AND PALÆONTOLOGY OF QUEENSLAND AND NEW GUINEA. With sixty-eight Plates and a Geological Map of Queensland. By ROBERT L. JACK, F.G.S., Government Geologist for Queensland; and ROBERT ETHERIDGE, junior, Government Palæontologist (New South Wales). Published under the authority of the Hon. W. O. Hodgkinson, Minister for Mines, etc., Queensland. Crown 4to. pp. xxx. and 768. Plates 68, and Map of 6 sheets. Brisbane: Beal. London: Dulau & Co., 1892.

TO bring within the compass of a single volume a description of the Geology and Palæontology of such an extensive area as the colony of Queensland must needs involve a great amount of arduous work, and when this has to be accomplished in the intervals of ordinary survey work, there is reasonable excuse for the delay which has taken place in bringing out this volume. As regards the geological portion, the delay has been advantageous in permitting the results of the latest surveys to be incorporated in it, but some of the palæontological investigations have been already anticipated by other authors. In Queensland, as in new countries generally, the portions first examined are those which promise to yield economic minerals, and hence the survey has been carried on in numerous isolated areas, and the geological boundaries of the intervening portions have been determined from the best information available. It will therefore be readily understood that the lines on the map, now published on the scale of 16 miles to an inch, will probably require modification when a more complete survey has been carried out. For the earlier geological work in Queensland we are indebted to the late Rev. W. B. Clarke, Mr. S. Stutchbury, Mr. Aplin, Mr. A. C. Gregory, and more especially to the late Mr. Richard Daintree. Since 1877, when Mr. Jack commenced his work in the colony, the survey has issued no fewer than 88 reports, most of which relate to mining areas.

From the introductory chapter we learn that the Eastern portion of Queensland, comprising from one-third to nearly one-half its area, consists of the remnant of a lofty table-land which reaches an elevation of over 5,000 feet, and from its Eastern edge has a short steep slope to the Pacific. This coast region consists of granites, syenites, basic igneous rocks, and of a series of stratified rocks, which in the lower portions are metamorphosed to a variable extent. The Western interior of the country presents a totally different aspect; for the table-land slopes away gradually towards the Gulf of Carpentaria and the south-west boundary of the colony, and the area consists of soft stratified Cretaceous rocks which form a good soil, though its fruitfulness is marred by a deficiency of rainfall. In some districts there are remnants of table-lands of the so-called Desert Sandstone, which apparently formerly extended over the Cretaceous clays, but fortunately has been largely denuded.

The list of the Geological Formations recognised in Queensland is not nearly so long as that of most European countries, but the authors state that the order of succession bears a general and striking resemblance to that worked out in Europe, though owing to the great distance separating these countries, they do not claim more than a homotaxial relationship for the Queensland formations which they have disposed under European names. Beginning at the top of the series, the post-Tertiary is represented by Bone-Drifts, Cave-Breccias, Sand-Dunes, etc.; in the Tertiary only the Pliocene and Miocene are doubtfully recognized; the former by the Upper, the latter by the Lower Volcanic and Drifts. In the Mesozoic Group, the Desert Sandstone, considered as Upper Cretaceous, rests unconformably on the Rolling Downs of Lower Cretaceous Age. Below these come the Ipswich rocks, forming the Upper Division of the Trias-Jura, whilst the Burrum series constitutes the Lower Division. Then comes in a strong unconformability, and below it the Bowen, Star, and Gympie divisions of the Permo-Carboniferous. Between these and the Burdekin group of Middle Devonian age there is another unconformity. The Burdekin is the lowest Formation containing determinable fossils, below it there are beds of stratified rocks succeeded by slates, schists, etc., of undetermined age.

Successive chapters are devoted to the description of the characters, the economical features, the fossils, and other particulars relating to each of these groups, commencing with the Plutonic and Metamorphic Rocks.

Some of the granites and syenites are stated to be distinctly metamorphic in character; alternate layers of coarser and finer material betraying an originally sedimentary origin. Tin, Silver-lead, Bismuth and Gold mines are present in some of the granite areas.

The metamorphic rocks are considered to have been originally limestones, conglomerates, siliceous and felspathic sandstones, clay-shales and mudstones, which are now generally thrown into sharp folds and locally metamorphosed into marbles, quartzites, greywackes, mica- and talc-schists, lydian stone or even into serpentines, diorites, hornblende and tourmaline gneisses. By Daintree and others large areas of these rocks were referred to the Silurian and Devonian; but Mr. Jack thinks that there is no direct evidence of the presence of Cambrian or Silurian strata in the country, and that the greater portion of the metamorphic rocks will prove to be of Permo-Carboniferous or Devonian age. Some of the richest Gold-fields in the colony, that of Charters Towers for example, occur in the metamorphic areas.

Devonian rocks have been recognized in at least five localities in Queensland. The most important outcrop on the Broken River is sixty miles in length by thirty in breadth. The rocks are mainly limestones, shales, sandstones and conglomerates, apparently forming a continuous series with an estimated thickness of 21,000 feet. These rocks contain a fairly representative series of corals and brachiopods, the species of which are all different from those in the succeeding Permo-Carboniferous Formation. The principal genera of corals belong to *Favosites, Heliolites, Pachypora,* and *Stromatopora,* and the brachiopods belong to *Spirifera, Atrypa, Rhynchonella, Pentamerus* and *Stringocephalus.* Some of the species are identical with those in the Middle Devonian of the Eifel and North America.

The Permo-Carboniferous rocks of Queensland have been ranged under the Gympie Beds, the Star Beds, and the Lower, Middle, and Upper divisions of the Bowen River Coal Field. The Gympie beds are the lowest; they consist of greywackes, sandstones, shales, breccias and limestones, together with volcanic rocks. Gold-bearing reefs are present in some districts, and they prove richest in connection with beds of black shale containing abundant remains of Polyzoa and Brachiopoda. In one shale-bed there are large isolated boulders of greywacke which the author considers to be erratics deposited by floating ice. The Gympie rocks were formerly placed as Devonian, but they are now believed to correspond with the Carboniferous or Lower Carboniferous of New South Wales. Some of the fossils correspond with those in the Middle Bowen Rocks, but there is a large number of species peculiar to each division.

The Star beds occupy a basin of about 36 square miles in extent, inclosed by granite and gneissoid rocks. They have yielded remains of *Lepidodendron, Calamites,* and other plants as well as numerous Brachiopods and Molluscs, some of which are common to the Gympie and Middle Bowen beds.

The Bowen River Coal-field extends from lat. 20° 30′ S. to lat. 26° S. In the lower division no organic remains have been discovered; it is separated from the Middle Division by a series of bedded volcanic rocks. The Middle Division consists of alternations of grey and yellow sandstones and blue and grey shales with occasional bands of ferruginous, probably once calcareous, sandstones. Two seams of coal occur in the series, and in some of the beds of fine sandy and muddy material there are large isolated boulders of granite, which Mr. Jack considers must have been deposited in their present position by ice action. The ferruginous sandstones abound in casts of fossils; in the shales the fossils are less numerous, but better preserved. The Upper Division of the Bowen River series consists almost wholly of shales and sandstones, probably about 1000 feet in thickness, in which there are numerous plant remains as well as Brachiopoda.

The *Flora* of the Bowen River series has somewhat of a Mesozoic character, for lycopodiaceous plants appear to be altogether absent; in the Middle Division *Glossopteris* is scantily represented, but in the Upper it is abundant. The occurrence of this genus amply confirms the statement that *Glossopteris* was associated with Palæozoic marine beds in New South Wales whatever its stratigraphical position in other countries might be.

The marine fauna of the Bowen River series is distinctly Palæozoic, and its Carboniferous facies can be readily recognized; at the same time a certain degree of relationship to the Permian is shown by the occurrence of forms of *Strophalosia*, *Stenopora*, and large Polyzoa of the *Protoretepora* type, and the resemblance of the *Producti* to the *P. horridus* of the Magnesian Limestone and Zechstein.

Corals are rare in the Permo-Carboniferous of Queensland, and the Rugosa are only represented by a few fragments. The Monticuliporoid genus *Stenopora* is abundant and four species are described. There are three very imperfectly preserved Blastoids, which are doubtfully referred to *Mesoblastus*, *Granatocrinus*, and *Tricœlocrinus*. *Phillipsia* is represented by two species, and there is also one of *Griffithides*. There are several species of *Fenestella*, but only casts of the zoarium are shown. Several species of *Spirifera* are present. Mr. Etheridge adopts the *G. Martiniopsis*, Waagen, for the *Spirifera subradiata* of Sowerby, and the *G. Derbyia*, Waagen, for the *Streptorhyncus crenistria* of Phillips.

The *Producti* are as a rule badly preserved; some of the familiar British forms are present in the Queensland strata, and they appear to be world-wide in their distribution. Species of *Strophalosia* and *Chonetes* also occur. The Pelecypoda are represented by numerous genera, and Mr. Etheridge proposes one new genus, *Deltopecten*, in the family of the Aviculopectinidæ, McCoy, and another, *Merismopteria*, in the family of the Aviculidæ. Several genera of Gasteropods, Pteropods, and Cephalopods are also present, and a few fish remains, doubtfully referred to *Deltodus* and *Palæoniscus*, complete the list.

The Lower Division of the Trias-Jura system, which succeeds unconformably the Permo-Carboniferous, consists of sandstones, shales and coals of the Burrum Coal-field. The age of these beds has been determined mostly by the plants, which show, with the exception of *Sphenopteris*, nothing in common with the plants of the underlying Permo-Carboniferous, but exhibit a strong Mesozoic facies.

The Higher Division of the Trias-Jura, or the Ipswich Formation, occupies an area of 12,000 square miles in the S.E. of the colony, and consists of conglomerates, sandstones, shales, with numbers of coal seams and some limestones. The coal-measures are covered with basaltic lava-flows. The fossils recognizable are almost exclusively those of plants, the only animal remains are a species of *Estheria*, a beetle, and some *Unios*.

The next succeeding Formation, named the Rolling Downs, is placed as the Lower Division of the Cretaceous; it is estimated to cover about three-fourths of the total extent of the colony. It consists of soft, crumbling, dark-grey shales, with bands of sandstone, ironstone and limestone, which rest nearly everywhere in the north of the colony, either on schists of undetermined age or on granite or gneiss, whilst in places it is conformably overlaid by the Desert Sandstone. The series is evidently of considerable thickness, and though mainly of marine origin, plant-beds and coal-seams occasionally occur in it. It is very rich in fossils, which include Foraminifera, Sponges, Brachiopods, Pelecypods, Gasteropods, and Cephalopods. Fragments of the skeletons of *Icthyosaurus* and *Plesiosaurus*, and specimens of the Mesozoic Ganoid *Belonostomus* have also been met with. Two new genera of the Aviculidæ are proposed by Mr. Etheridge for shells occurring in this division; one, *Pseudavicula*, of which the type is *Lucina anomala*, Moore, and the other *Maccoyella*, for *Avicula Barklyi*, Moore. Mr. Etheridge considers that the Rolling Downs Formation contains an admixture of Oolitic as well as Cretaceous forms. The most prevalent fossils in it are *Inoceramus* and *Belemnites*.

The Desert Sandstone, which is considered to be of Upper Cretaceous age, is thought to have formerly covered three-fourths of the colony, but it is now restricted to narrow areas of table-lands which rest on the Rolling Downs Formation and older rocks. It appears principally to consist of sandstones and conglomerates, mostly of quartz pebbles. Some portions of these rocks may possibly be of lacustrine origin, whilst in others shells of *Ostræa* and other marine bivalves occur. A few plant remains have also been found in this formation; the most important of these are specimens of undoubted *Glossopteris*, a fern which has been by some authorities considered characteristic of Palæozoic strata, though Prof. McCoy restricted it to the Mesozoic. In Queensland, previous to its discovery in the Desert Sandstone or Upper Cretaceous, it was only known from the Permo-Carboniferous of the Bowen River Coal-field. The same genus, as is well-known, occurs in the Jurassic strata of India.

There is no distinct evidence of the occurrence of Tertiary strata in Queensland, but this period seems to have been marked by movements of elevation accompanied by great volcanic activity. The volcanic rocks have been divided into a Lower series, which was laid down after the elevation of the Desert Sandstone and before it had been denuded to any great extent; and an Upper series, which belongs to a subsequent period of eruption, of which the vents are still extant.

In all parts of the colony the remains of extinct birds, reptiles and mammals have been found in the post-Tertiary Fluviatile Drifts, mostly in breccias and indurated muds which represent the beds of old water-courses through which the present creeks have cut their channels. Very little attention appears to have been given to these fossils at present. The shells of fresh-water Molluscs associated with these vertebrates, all appear to belong to existing species. No human bones, flint-flakes, or native weapons, have ever been found associated with extinct mammalia in Queensland.

The chapter on the Geology of British New Guinea is based mainly on the report of Mr. A. Gibb Maitland, of the Geological Survey of Queensland. From this it appears that on the north-east coast of this island there are numerous raised coral reefs, presenting all gradations of height from only a few feet above the water to an elevation of 2000 feet. Beds of sandstone and grit in the Kevori district are considered to be of post-Tertiary age, and the sandy limestones and shales with flint nodules at Port Moresby are regarded as Tertiary. An immense area, extending from Port Moresby to the German boundary, is occupied by metamorphic rocks. From the fossils obtained from different sources, Mr. Etheridge has determined that the oldest fossiliferous rocks in New Guinea, known up to the present, probably correspond homotaxially with the Upper Oolites of other countries.

In the concluding chapter petrographical notes on specimens from Queensland and adjoining countries are contributed by Mr. A. W. Clarke, F.G.S.

A very complete index, arranged under the headings of Persons, Places, Subjects, and Genera, Species and principal Synonyms, greatly facilitates the work of reference, and Mr. Etheridge also gives a list of papers relating to the Palæontology of Queensland and New Guinea. To this list a paper by Mr. A. H. Foord on Western Australian Fossils (Geol. Mag. Vol. VII. 1890) giving references to forms occurring in Queensland, might be added.

The plates illustrating the fossils, rock specimens, etc., are bound in a separate volume. The major portion were drawn and lithographed in this country by Messrs. Berjeau and Highley, and it is hardly necessary to add that they reach a high standard of excellence which could hardly be looked for in the plates executed in Queensland.

The importance of this work as a solid contribution to geology generally, and its particular value to that of Queensland, require no comment; and its authors deserve the acknowledgments of all interested in the science. We are also glad to see that the Government of Queensland recognizes the value of the work in making known the mineral resources of the colony.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 12th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Palæozoic Ostracoda from Westmoreland." By Prof. T. Rupert Jones, F.R.S., F.G.S.

In 1865 the author determined for Prof. Harkness some fossil Ostracoda which he had obtained from the Lower Silurian rocks of S E. Cumberland and N.E. Westmoreland, and subsequently other specimens mentioned by Harkness and Nicholson in 1872. In

1891 Prof. Nicholson and Mr. Marr submitted a series of similar microzoa from the same district; and the author now endeavours to determine their specific alliances, and revises the list of those previously collected. He has to notice about eleven forms of *Primitia*, *Beyrichia*, *Ulrichia*, *Æchmina*, and *Cytherella*—several of them being closely allied as varieties, but all worthy of study as biological groups, such as have been illustrated from other regions by writers on the Ostracoda, with the view of the exact determination, if possible, of species and genera, of their local and more distant or regional distribution, and of their range in time.

2. "On some Palæozoic Ostracoda from the Girvan district in Ayrshire." By Prof. T. Rupert Jones, F.R.S., F.G.S.

This paper aims at the completion of the palæontological account of the Girvan district, as far as the Ostracoda are concerned; and follows up the researches indicated in the "Monograph of the Silurian Fossils of the Girvan District in Ayrshire," by Nicholson and Etheridge, vol. i. 1880.

In about a dozen pieces of the fossiliferous shales, submitted for examination some few years ago, the writer finds nearly thirty specimens of *Primitia*, *Beyrichia*, *Ulrichia*, *Sulcuna*, and *Cypridina*, which show interesting gradations of form, not always easy to be defined as specific or even varietal, but valuable as illustrating modifications during the life-history of individuals, thus often leading to permanent characteristics of species and genera. Like those formerly described in Nicholson and Etheridge's "Monograph," the specimens have all been collected by Mrs. Elizabeth Gray of Edinburgh.

3. "On the Dwindling and Disappearance of Limestones." By Frank Rutley, Esq., F.G.S.

The existence of chert between two sheets of eruptive rocks at Mullion Island seemed to the author to require some explanation. Cherts are usually associated with limestones, and the absence of limestones in many cases where cherts are found points to their removal by underground waters. The older the limestone, the greater the probability of its thickness having dwindled. The thicknesses of the Ordovician, Silurian, Devonian, and Carboniferous Limestones seem to be in the ratio of 1 : 15 : 15 : 100. Many limestones once existing in Archæan rocks may have disappeared, as also limestones in later rocks.

The author comments on the difficulty of distinguishing some cherty rocks from felstones.

Two Appendices are added to the paper, the first on the transference of lime from older to newer deposits, and the second on the formation of nodular limestone bands.

4. "On some Bryozoa from the Inferior Oolite of Shipton Gorge, Dorset.—Part II." By Edwin A. Walford, Esq., F.G.S.

As we pass backward in time, the characters of the two sub-orders Cheilostomata and Cyclostomata merge. The accessory organs of the genus and species described in this paper illustrate this statement. The genus is named *Pergensia*, and the following new species are described:—*P. nidulata*, and vars. *major* and *minima*, *P. porifera*, *P. amphoralis*, *P. jugosa*, *P. bigibbosa*, and *P. galeata*. This genus is, however, placed in the sub-order Cheilostomata, thus recognised for the first time in the Jurassic Series.

II.—April 26th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Origin of the Crystalline Schists of the Malvern Hills." By Charles Callaway, D.Sc., M.A., F.G.S.

This paper was the third of a series of three. In the first of these, published in the Quarterly Journal in 1887, the author contended that many of the gneisses and schists of Malvern were formed out of igneous rocks. In the second, which appeared in the Journal in 1889, he discussed the origin of secondary minerals at shear-zones in the Malvern rocks, and arrived at the conclusion that all the mica and much of the felspar, to say nothing of quartz and other minerals, were of secondary origin. In the present paper the author first pointed out that some of the most important mineral changes described in his second communication—such, for example, as the conversion of chlorite into biotite—had since been confirmed by independent investigators. He held that, as a whole, the gneisses and schists of Malvern had been formed by the crushing and shearing of consolidated igneous rocks; but he did not deny the possibility that here and there the foliated structure might have been produced in a fused mass. In the first stage of metamorphism the diorite or granite was crushed and decomposed. This slightly compressed rock could be traced step by step into a typical gneiss or schist. The signs of pressure progressively increased, and the mineral and chemical changes became proportionately greater. Reconstruction set in. The process of metamorphism did not always follow the same lines. Felspar was sometimes crushed into seams of fragments, and these, by partial re-fusion and pressure, were converted into gneissose lenticles of quartz and felspar. Intervening chlorite was changed to biotite, or even to muscovite or sericite. Thus a typical gneiss, consisting of quartz-felspar lenticles in a felt-work of mica, was formed out of a diorite. Sometimes the felspar was reconstituted without becoming fragmental, and it was then deposited on, or it included, idiomorphic mica; or a soda-lime felspar might, by a process of corrosion, be converted into quartz, or a soda-felspar, or both.

In an early stage of metamorphism, the rock was often dirty and rotten through the abundance of chlorite and disseminated iron-oxide. The former being changed to mica, and the latter being either absorbed in the production of biotite, or reconstituted in a crystalline form, a sound clear gneiss was the result. In the completed product, the signs of crushing and shearing were often entirely wanting. Even strain-shadows were rare in it. The metamorphism, however, was demonstrated in numerous localities by tracing the gradations inch by inch, and by the subsequent study of large numbers of microscopic slides, in which the transition was still more clearly seen than in the field.

The classification of the Malvern schists originally proposed was somewhat enlarged, the injection schists being subdivided into (1) Schists of Primary Injection, in which one rock was injected into another, and (2) Schists of Secondary Injection, formed by the infiltration of secondary minerals along shear-planes.

One of the most important of the chemical changes produced in the conversion of a diorite into an acidic schist was the elimination of magnesia. This was proved by analyses. The recent researches of Mr. Alexander Johnstone had shown that even in the laboratory, and at the ordinary temperatures, carbonated waters were able to remove magnesia from certain of its combinations with silica.

2. "Supplementary Notes on the Metamorphic Rocks around the Shap Granite." By Alfred Harker, Esq., M.A., F.G.S., and J. E. Marr, Esq., M.A., F.R.S., Sec.G.S.

This paper contains some additions and corrections to the work submitted to the Society by the authors on a previous occasion (see Quart. Journ. Geol. Soc. vol. xlvii. p. 266). In the present communication special attention is paid to the alteration of a group of basic volcanic rocks by the granite.

III.—May 10th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

1.—"The Felsites and Conglomerates between Bethesda and Llanllyfni, North Wales." By Prof. J. F. Blake, M.A., F.G.S.

The author brought forward fresh evidence in support of the views he had previously expressed as to the Cambrian age of these felsites, and as to the unconformity of the conglomerates on the Purple Slates.

A new Tunnel Section at Penrhyn Quarry was described, in which felsite was followed by St. Ann's Grit with a Conglomerate-band, and there lying in the midst of the Cambrian Series. After a word or two on the conglomerate on Moel Rhiw-wen, the sections on either side of Llyn Padarn were discussed in detail, and it was shown that the distribution of the rocks on the surface of the country could only be explained by the unconformable position of the conglomerates and grits, which, moreover, lie nearly horizontal.

After a discussion of the conglomerates of Bettws-Garmon, a detailed section of the adit at Moel Tryfaen was given, in which it was shown that there was only a 3ft. 6in. band of conglomerate next the Purple Slates, followed by 1350 feet of Banded Slates and Laminated Grits with four distinct intercalated bands of felsite; and it was argued that the conglomerate on the summit, 55 yards across, could scarcely be represented by this thin band. Finally, the distribution of rocks on Mynydd-y-Celgwyn was shown to be satisfactorily explained by unconformity.

Incidentally it was mentioned that a band of rock in the felsite at Llyn Padarn, which had been considered to be a deposited slate, was in reality an intrusive igneous rock.

The conglomerates described were considered to be an overlap of the Bronllwyd Grit.

CORRESPONDENCE.

CLAIM OF PRIORITY.

Sir,—My friend Mr. G. C. Crick, of the British Museum (Nat. Hist.), has drawn my attention to the fact that Mr. S. A. Miller, of Cincinnati, has proposed (Advance Sheets, 18th Report, Geol. Surv. Indiana, p. 71) a new genus—*Streptodiscus*—for *Nautilus stygialis*, de Koninck, and its allies—to replace *Trematodiscus*, erected by Meek and Worthen (Proc. Acad. Nat. Sci. Philadelphia, 1861, p. 147), and *Trematoceras*, proposed by Hyatt in 1883, both these names being preoccupied, the first by Häckel for a genus of Radiolarians, the second by Eichwald for a *Bactrites*, and also (according to Mr. Miller) by R. P. Whitfield in 1882, for a (fossil) Cephalopod. I must be permitted, however, to point out to Mr. Miller, and to all whom it may concern, that I proposed the name *Cœlonautilus* for *Nautilus cariniferus*, Sowerby, first in a paper by Mr. G. C. Crick and myself (Geol. Mag. Decade III. Vol. VI. p. 494, 1889), and afterwards, with a full description of the genus in the "Catalogue of the Fossil Cephalopoda in the British Museum (Natural History)," Part II. 1891, p. 105, I enumerated in this place the following species as falling within *Cœlonautilus*, viz. *Nautilus stygialis* (as type), *N. Edwardsianus*, *N. Omalianus*, and *N. pinguis*, de Koninck (not *N. pinguis*, M'Coy), together with *N. sulcatus*, *N. cariniferus*, etc. of J. de C. Sowerby.

Arthur H. Foord.

Dublin, *April* 14, 1893.

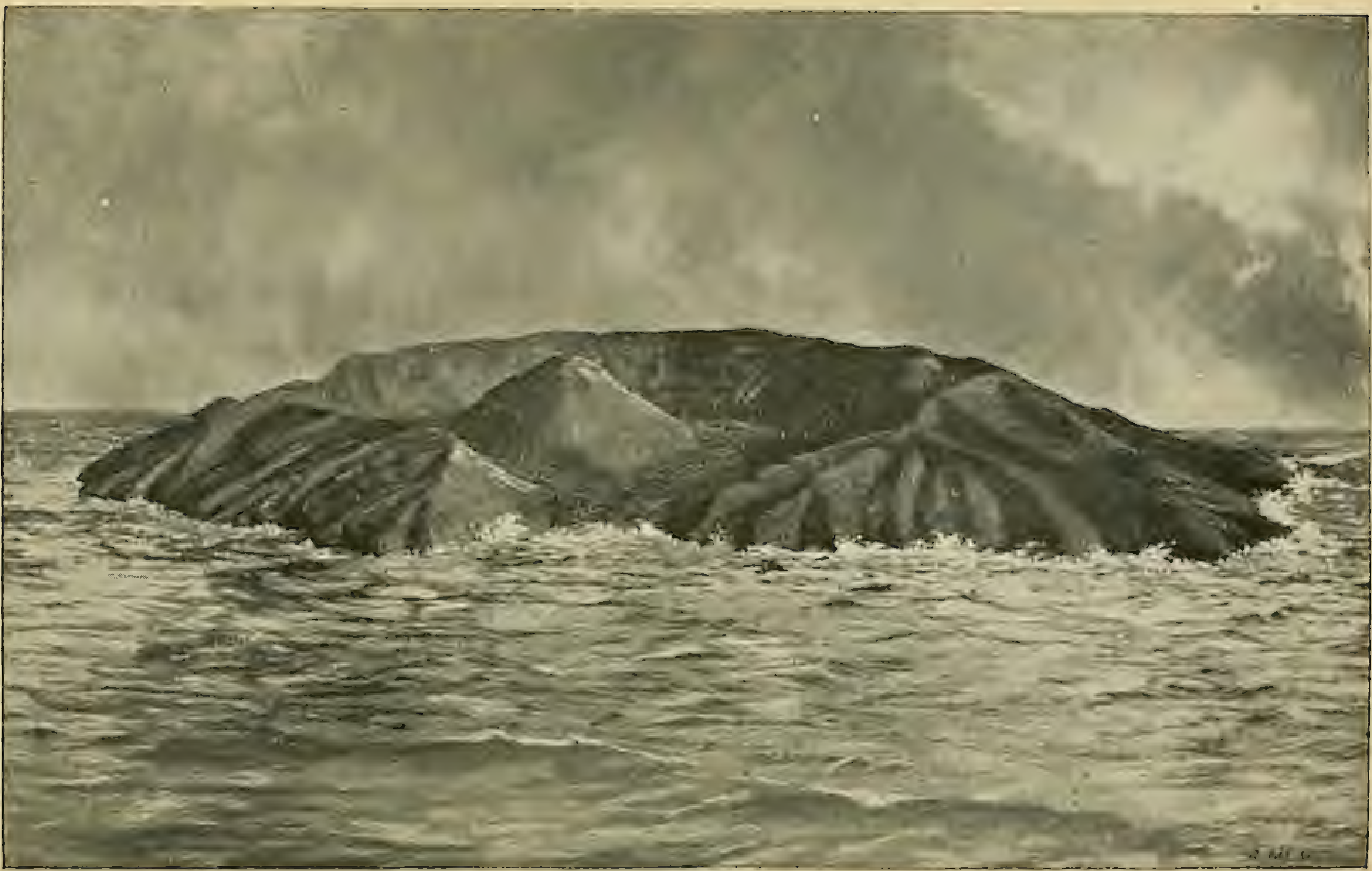
MISCELLANEOUS.

The Murchison Gold-field.—Western Australia has lately added another Gold-field to its possessions, the proclaimed area of which is 32,000 square miles. This field was discovered in 1891 and has just been reported upon[1] by Mr. Harry Page Woodward, F.G.S., the Government Geologist for the Colony. The principal auriferous belt is situated on the eastern side of the area, about 200 miles from the coast, running in a north and south direction. Taken as a whole, the field is exceedingly rich, and will probably extend for a great distance eastwards. Water is abundant and at shallow depths, for which the district is celebrated; timber is scarce. This field has a brighter outlook than any other in the Colony, having neither the distance to Kimberley nor the salt-water of Yilgarn to contend with. On the east side of the Weld Range, is the celebrated "Wilgie Myah," probably one of the largest Iron-lodes in the world, composed almost entirely of hæmatite in immense botryoidal masses. The natives quarry it to obtain the red and yellow ochre with which they love to adorn their persons. The place has probably been worked by the aborigines for hundreds of years before the white man set foot in Australia.

[1] Issued in Perth, W.A., April, 1893.

Erratum.—Readers of the Geological Magazine are requested to make the following correction in legend to woodcut on p. 207 of Prof. Bonney's article in the May Number, 1893:—

For "*G* seems to *quadrate in A*," etc., read "*G* seems to *graduate into A*," etc.



View of Barren Island—Bay of Bengal.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. VII.—JULY, 1893.

ORIGINAL ARTICLES.

I.—The Volcanoes of Barren Island and Narcondam in the Bay of Bengal.

By V. Ball, C.B., LL.D., F.R.S.,
Director of the Science and Art Museum, Dublin.

Third Notice.[1]

(PLATE XIII.)

ALTHOUGH it is now nearly twelve years since I left India, my interest has not abated in the scenes and subjects of former labours in that country, and I am still careful to note anything which is published in reference to them. This practice enabled me to add some facts to the history of the two above-named volcanoes in my *Second Notice*, besides quoting from the account by Mr. F. R. Mallet, the principal results of his survey made in conjunction with Captain Hobday, eleven years after my visit to them, which took place in the year 1873.

It has always seemed to me to be somewhat unfortunate that no adequate representation of the peculiar forms of the crater and cone of Barren Island has hitherto been published; and, as a consequence, the resemblance which this volcano bears to some of those on our satellite the Moon, though referred to, has never been effectively portrayed. In order to obtain such a representation I have had recourse to a device, the result of which will, I think, be admitted to be more satisfactory than the ideal sketches, from a bird's-eye point of view, which have been published.

Two or three years ago I had a model of the island constructed on the scale of 20 inches to a mile from data given in Mr. Mallet's paper. This model has since been photographed, and by combining the negative with suitable sea and sky negatives, the picture now reproduced has been arrived at.

Of course, on strictly artistic grounds, objection might be raised to the method which has been adopted; but as this pictorial diagram represents with close approach to accuracy the appearance of the island as it might be seen from a balloon, it subserves in a very special degree the main object aimed at, and will, I trust, prove acceptable to all interested in volcanic phenomena, whether terrestrial or otherwise. Possibly too, the above description of the method which has been followed may suggest to others, who may not have tried it, a graphic means of illustrating geological structure of more or less analogous character.

---

[1] First Notice, Geol. Mag. Vol. VI. 1879, pp. 16–27. Second Notice, Geol. Mag. Dec. III. Vol. V. 1888, No. IX. p. 404.

NOTES ON THE FAUNA.

Some few remarks on the fauna of these Oceanic islands, as they may be called, with special reference to the light thrown by it on the question of their antiquity, may, perhaps, be suitably added here, especially as the subject has not been alluded to in my previous communications.

While the volcano now called Narcondam is absolutely extinct and there is no historical record of its having ever been in a state of activity, the volcano forming Barren Island is only in a quiescent stage and towards the end of the last century and the beginning of this it appears, as has been described on previous pages, to have been in such a condition of disturbance that all the animal and vegetable life previously existing upon it, was in all probability destroyed.

The characteristics of the faunas of both islands, so far as they are at present known, support these conclusions. The animals found on both are immigrants; they consist chiefly of birds and insects. Some of them are no doubt voluntary visitors such as the raptorial birds, pigeons of strong flight, and aquatic species. There is, however, one important species found on Narcondam only, which testifies to long continued quiescence on that island.

It is a hornbill, of which, when we landed on the island in 1873, two specimens were obtained and they proved to belong to a species previously unknown.[1]

As there are no hornbills in the Andaman or Nicobar Groups, the progenitors of this species must have arrived from some far distant region in Indo-China, or possibly in the Malayan Archipelago; and their descendants have since developed the specific characters which serve to characterize the species. This fact may alone be taken to indicate a long period of time, during which the island was, moreover, probably not devastated by fire.

On the cliffs of Narcondam, in quite inaccessible positions, there were nests of *Collocalia*, or rock swiftlets, specimens of which I obtained by shooting, and they proved to consist of seaweed agglutinated by mucilage, and quite different from the true edible nests, which were thus proved to be the work of a distinct species.

As for Mammals and Reptiles there is little to be said; the former are represented on Narcondam by a local variety (?) of very dark colour, of *Pteropus*, or Flying Fox, which may have been first carried thither by the wind. On both islands rats are found, *Mus Andamanensis* which, possibly, like the few reptiles, namely, *Hydrosaurus* and Skinks, may have arrived on drift timber.

In general it may be said that the character of the Vertebrate fauna indicates its own derivation, through the influence of the S.W. Monsoon, from the Andaman Islands, which are about 90 miles distant, and it would seem that the insects which have been collected of late years point to the same conclusion.

---

[1] *Rhyticiros Narcondami*, Hume.

The attempts which have been made from time to time to naturalize goats and fowl on these islands with the charitable object of affording food to those who may be shipwrecked there, has been unsuccessful, owing possibly to the absence of a perennial supply of fresh water on Narcondam and the brackish character of the hot spring on Barren Island.

I have not as yet seen a promised account of the flora of these Islands by Dr. Prince. Doubtless it deals or will deal with evidence similar to that afforded by the fauna.

II.—ON THE BRITISH EARTHQUAKES OF 1892.

By CHARLES DAVISON, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

DURING the past year a comparatively large number of earthquakes have been felt in Great Britain, the most notable being those which originated within a short distance from Pembroke, between the 17th and 22nd August. This series will form the subject of a separate memoir. In the present paper are given a list of the earthquakes of 1892, complete so far as I can make it, with descriptions of three important shocks felt in the parish of Loch Broom (Ross-shire) on March 4, and in south-west Cornwall on May 16 and 17.

It is my pleasant duty to express my obligations and to offer my hearty thanks to the numerous observers who have assisted me in my work. Many of the accounts which they have communicated are of great interest and value, and I much regret that it is impossible to insert them all here. It was necessary to make some selection, and those only are given which, from various circumstances, happen to throw most light on the origin of the shocks. Every note, however, has been considered, and has been of some service in writing these descriptions; and I trust that, if any of my correspondents should happen to see these pages, they will not think their kindness and trouble have been thrown away if their own reports do not appear in full. May I also add how grateful I should be for notice—especially early notice—of any earthquake, whether real or only suspected to be such? The completeness of the seismic record in a given district is of the first importance; and, if Great Britain forms a region in which shocks are slight and somewhat rare, there are yet parts of it whose seismic history would help towards the solution of several geological problems.

As in previous papers,[1] the hours are numbered from 0 to 24; the time being Greenwich mean time. The intensity is estimated in terms of the Rossi-Forel scale.[1] The epicentrum is really an area, the projection of the seismic focus or centrum on the earth's surface. As, however, I have no means of determining the form of this area, I have given instead, the position of the point vertically, or nearly so, above the centre of intensity of the focus.

---

[1] On the British Earthquakes of 1889, GEOL. MAG. Dec. III. Vol. VIII. 1891, pp. 57–67, 306–317, 364–372. On the Inverness Earthquakes of November 15 to December 14, 1890, Quart. Journ. Geol. Soc. vol. xlvii. 1891, pp. 618–632. On the British Earthquakes of 1890, with the exception of those felt in the neighbourhood of Inverness, GEOL. MAG. Dec. III. Vol. VIII. 1891, pp. 450–455. Record of Observations on the Inverness Earthquake of November 15, 1890, Birmingham Phil. Soc. Proc. vol. viii. 1891. On the British Earthquakes of 1891, GEOL. MAG. Dec. III. Vol. IX. 1892, pp. 299–305.

On the maps, the position of the epicentral point is indicated by a star. Places where the shock was felt is indicated by small black discs; those where it was not felt (by several or many persons) by small circles. A cross drawn through a disc or circle indicates that the usual earthquake-sound was also heard there; a cross alone, that the sound was the only phenomenon recorded, but not necessarily implying that the shock was not also felt.

LIST OF EARTHQUAKES IN 1892.

In the following list, only those shocks are recorded that were felt by at least two observers. For the notes relating to those at Invergarry and Ardochy, I am again indebted to Mr. John Grant and Mr. Murdoch Matheson, who have continued their valuable work of recording the earthquakes of that part of Inverness-shire. Mr. Matheson informs me that all the Ardochy shocks were felt by at least four persons.

Feb. 29, 22h. 35m., Ardochy. A slight shock, accompanied by a low rumbling noise: duration of sound, 40 seconds.
„ 23h. 15m., Ardochy. Duration of shock, about 15 seconds: intensity, IV.; preceded by a low rumbling noise.
Mar. 4, about 7h. 30m., Loch Broom.
Apr. 3, 7h. 35m., Ardochy. A slight shock like the passing of a carriage.
May 16, about 22h. 30m., South-west Cornwall.
„ 17, about 1h. 30m., „ „
Aug. 17, about 23h. 30m., Pembrokeshire. A slight shock.
„ 18, 0h. 23m., South-west of Pembrokeshire. A sound like distant thunder heard.
„ „ 0h. 25m. Principal earthquake (intensity, nearly VIII.), felt most strongly in Pembrokeshire, but perceptible throughout nearly all Wales, in the west and south-west of England and the south-east of Ireland; disturbing at least 26 counties.
„ „ 0h. 37m., Pembrokeshire.
„ „ about 1h. 5m., Pembrokeshire. A very slight shock.
„ „ about 1h. 40m., Pembrokeshire and adjoining counties, Devonshire and Wexford. The strongest shock but one of the whole series.
„ „ about 2h. 40m., Pembrokeshire.
„ „ about 4h., South-west of Pembrokeshire. A slight shock.
„ 22, about 11h. 55m., Pembrokeshire.
Sep. 25, 8h. 13m., Invergarry. A rumbling noise, lasting about 4 sec.

---

[1] A translation of the Rossi-Forel scale of seismic intensity is given in the GEOL. MAG. Dec. III. Vol. VIII. p. 58; Nature, vol. xlii. 1890, p. 349.

Oct. 24, 10h. 10m., Ardochy. Duration of shock, several seconds; intensity, IV.; preceded, accompanied, and followed by three distinct rumbling noises, of which the first was the loudest.

Nov. 18, 2h. 17m. or 14h. 17m., Ardochy. A slight shock, followed by a slight rumbling noise.

The following are recorded by only one observer: (1) Aug. 19, 9h. 30m., St. David's (Pembrokeshire); a rumbling noise heard, without any accompanying vibration. (2) Aug. 23, 4h. 30m., Pembroke Dock; a shock of intensity, IV. (3) Sept. 11, at or some time after 1h. 23m. (the observer's watch had stopped at this time), Watertown near Northam (North Devon); three successive very slight impulses, accompanied by a rolling sound, apparently at a great distance below but to the south-west. I am indebted for this record to Mr. T. Mann Jones, F.G.S.

LOCH BROOM EARTHQUAKE: MARCH 4, 1892.

Time of occurrence, about 7h. 30m. Intensity, V. Epicentrum, 6 miles N. 26° W. of Ullapool, *i.e.* in lat. 57° 58′ 30″ N., long. 5° 13′ 30″ W.

Disturbed Area and Intensity.—I have received 37 records[1] of this earthquake from 33 different places. Most of these places are close to the sea, but the coast in this part of Ross-shire is much indented, and the data are sufficient for determining the boundary of the disturbed area, though no doubt somewhat roughly. Besides these definite records, I am informed by Mr. R. MacRae that both shock and sound were noticed to the extreme end of the peninsula of Coigach; and by Mr. A. McKenzie that the shock was felt on the south side of Little Loch Broom.

The intensity of the shock was V. at Isle Martin; and IV. at Achduart, Achiltibuie, Achnahaird, Achninver, Ardindrean, Badinscally, Badintarbet, Culcraig, Inverlaal, Isle Tanera, Kildonnan, Leckmelm, Lochinver, Morefield, Polglass, Scorraig, Scot Rae, Strathmore, and Ullapool.

The boundary of the disturbed area corresponds to an isoseismal of intensity IV. This line includes an area 28 miles long and 17 miles broad, and contains about 364 square miles, its centre being at a point 6 miles N. 26° W. of Ullapool. The longer axis is directed approximately N. 30° W. and S. 30° E.

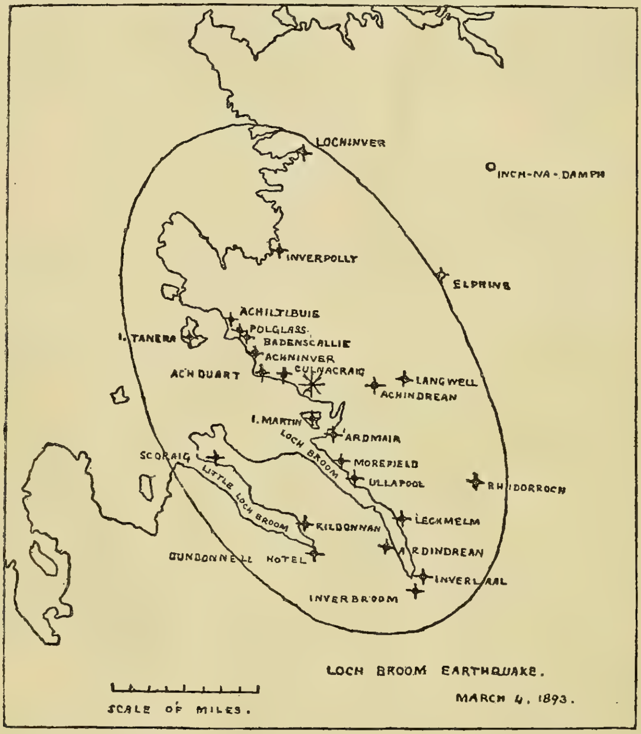
Nature of the Earthquake-Phenomena.—Of the six places from which records are here given, Dundonnell Hotel lies near the head of Little Loch Broom; and the other five are close to the longer axis of the disturbed area.

Inverbroom (Observer, Mr. J. A. Fowler, yr., of Braemore).—The shock like going over two or three small waves in a small boat; duration, three to four seconds. A very loud rumbling, as of a heavy waggon driven rapidly over a granite-paved road, preceded and coincided with the shock.

---

[1] For several of these records, as well as for their own observations, I am much indebted to the kindness of Mr. D. Fraser and Mr. R. MacRae, of Achiltibuie, Miss E. Lang, of Ardindrean, Mr. M. McKenzie, of Achindrean, Mr. W. Matheson, of Isle Tanera, and Mr. J. S. Stewart, of Isle Martin.

Ardindrean (Observer, Miss E. Lang).—About five or six vibrations, lasting about three seconds. The sound like that of a carriage passing close by the house, becoming gradually louder and then dying away; both beginning and end coinciding with those of the shock; the principal vibrations felt when the sound was loudest.



Dundonnell Hotel (Observer, Mr. J. A. Whyte).—Without any previous warning, a violent *thud* heard as if some heavy body had fallen in the adjoining room. This was immediately followed by a slight vibrating movement lasting about four or five seconds, during which was heard a very faint booming sound, that died away about a second before the tremor.

Ullapool.—The shock resembled the effect produced by the fall of a heavy body, followed by a rumbling noise that lasted about seven seconds.

Isle Martin (Observer, Mr. J. S. Stewart).—Vertical motion perceptible, first upward and then downward; duration of shock, about six seconds. A rumbling noise heard, resembling at first the boom of a cannon and afterwards distant thunder; the sound followed the shock immediately without intermission.

Achiltibuie.—(1. Observer, Mr. D. Fraser.) One series of vibrations, lasting about three or four seconds. A rumbling sound, beginning like a shot from a gun and dying away like a heavy chain dropping from a ship; the vibrations felt when the sound was loudest; the end of the sound followed that of the shock by about five seconds.—(2. Observer, Mr. R. MacRae.) A tremulous motion, the vibrations too rapid to be counted and all apparently of the same intensity. A rumbling sound like that of a conveyance passing over a gravel road some distance away; the beginning coincided very nearly with that of the shock; the end followed that of the shock by a very short interval.

It will be seen that the disturbed area and the sound-area are approximately coincident. At Elphine, however, which is near the north-east end of the shorter axis of the disturbed area, the shock was not felt, while a rumbling sound was heard by Mr. A. Hunter like that of a gig passing along the road close by. Mr. Hunter was good enough to make several enquiries in the neighbourhood. About one mile nearer Ullapool, the sound, he finds, was heard and no shock felt, but the observer was standing, and in the open air, an unfavourable position for perceiving a slight vibration. At Ledmore, about two miles east of Elphine, neither shock nor sound were perceived. In the absence of detailed records from the south side of Little Loch Broom, it is impossible to say whether the disturbed area and sound-area were, or were not, concentric.

Time-relations of the Shock and Sound.—The beginning of the sound is said to have preceded that of the shock at Inverbroom, Inverlaal, and (by a very short interval) at Morefield; coincided with it at Achiltibuie, Ardindrean and Lochinver; and followed it at Kildonnan and (by a very short interval) at Dundonnell Hotel, Isle Martin and Ullapool.

The end of the sound is said to have preceded that of the shock at Dundonnell Hotel; coincided with it at Ardindrean and Lochinver; and followed it at Achiltibuie.

Origin of the Shock.—The broken character of the country may be answerable to some extent for the elongated form of the disturbed area, and on this account it would be unwise to lay too much stress on the position of the epicentrum and the direction of the longer axis as determined above. Taking them as they stand, however, we should infer that, if the shock were fault-formed, the direction of the fault-line should be N. 30° W. and S. 30° E. The best guide as to the direction of hade is the greater intensity of the shock at Isle Martin than elsewhere; and, this place lying to the south-west of the longer axis, it would follow that the fault must hade towards the south-west; a conclusion supported by the sound being perceived immediately after the shock at Isle Martin, and also, perhaps, by the overlapping of the sound-area in the neighbourhood of Elphine. The fault-line must in that case lie on the north-east side of the axis, parallel to it and distant from it probably about one mile and not more than two or three miles. The length of the seismic focus in a horizontal direction must have been considerable, perhaps several miles; and the observations on the time-relations of the shock and sound show that the slip must have died out slowly towards the south-east and rapidly towards the north-west. Lastly, the observations at Isle Martin and Inverbroom on the first direction of the vertical motion would seem to indicate that the relative movement of the rock on the downthrow side must have been downwards, that is, that the slip must have increased the throw of the fault and possibly also tended to increase the depth of Loch Broom.

Authorities.—Besides those already mentioned I am indebted to the following observers for accounts of this earthquake: Achduart, Miss M. MacLennan; Inverlaal, Mr. M. M'Lean; Kildonnan, Mr. A. McKenzie; Lochinver, Mr. A. Beveridge; Morefield, Mr. A. Ross; Scorraig, Miss A. Cameron; Ullapool, Rev. J. MacMillan. The account of the shock at Ullapool given above is taken from a paragraph (probably copied) in the "Birmingham Daily Post" for March 7, 1892.

S. W. CORNWALL EARTHQUAKES: MAY 16–17, 1892.

During the night of May 16–17 two distinct earthquakes were felt in south-west Cornwall, the first at about 22h. 30m. on May 16, the second and stronger at about 1h. 30m. on May 17. According to one report (from Porthleven), several shocks of a slighter character were felt in the interval between them; but, this being the only evidence I have been able to obtain, their occurrence must be regarded as doubtful though it is worthy of notice that Porthleven is one of the five places where the principal shock was most severe.

I may refer here to a report printed in several newspapers that, on the afternoon of May 17, the water in Mount's Bay, and especially in Penzance Harbour, was tinged with a decided yellow colour; and this was generally considered, I believe, as a result of the earthquake. But Mr. J. Morrish, Dock and Harbour Master at Penzance, informs me that this discolouration had been noticeable for at least a fortnight previously. Whatever may have been its origin, it cannot therefore, as he observes, have had any connection with the shocks.

First Shock: May 16.

Time of occurrence, about 22h. 30m. Intensity, IV. Epicentrum, about 1¼ miles N.E. of Wendron, *i.e.* in lat. 50° 8′ 30″ N., long. 5° 13′ 5″ W.

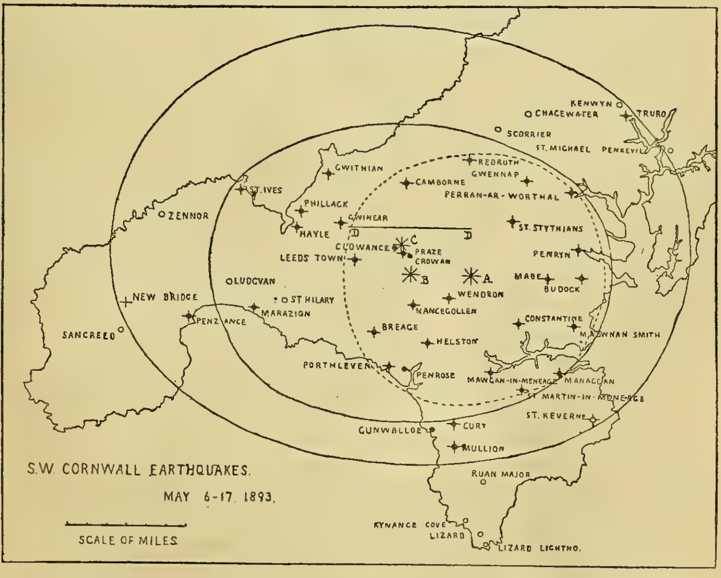
This shock, being the first and also an exceedingly slight one, was felt or recorded by very few observers. I possess only nine accounts from eight different places, namely, Breage, Budock, Manaccan, Mawgan-in-Meneage, Nancegollen, Perran-ar-Worthal, Porthleven, and St. Stythians. At Breage, the intensity of the shock was IV. and a loud rumbling sound was heard, lasting two or three seconds. At Mawgan-in-Meneage, the noise, which was not so loud as that of the principal shock, seems to have been the only phenomenon observed. From all the other places, the records consist of little more than the statement that a slight shock was felt.

The boundary of the disturbed area is shown on the map by a dotted line. In form it is roughly circular, but from the north-west quarter there is no evidence of a reliable character. This portion may therefore be incorrectly drawn, but the position of the epicentrum in all probability does not differ greatly from that given above. Assuming the accuracy of this boundary line, the area disturbed must have been about 12½ miles in diameter and have contained about 120 square miles.

Second Shock: May 17.

Time of occurrence, about 1h. 30m. Intensity, nearly V. Epicentrum, 3½ miles N. 15° W. of Helston, *i.e.* in lat. 50° 8′ 30″ N., long. 5° 18′ 0″ W.

Disturbed Area and Intensity.—The following discussion is founded on 70 records from 40 different places. These places are shown on the accompanying map, which, with the exception of the dotted line, refers entirely to this earthquake. For so slight a shock the number of records is unusually great, and this is due to the kindness of several gentlemen who, at the cost of much trouble, made further inquiries within and near the disturbed area. The Rev. Canon Rogers, of Gwennap, has sent me several accounts from that village, from Redruth and other places; accounts which have added very materially to our knowledge of the shock. For six records from Marazion I am indebted to Mr. Fortescue Millett, and for others from the neighbourhood of Hayle to Dr. Cleaver, of Hayle, and the Rev. F. Hockin, of Phillack.



The intensity of the shock was greater than IV. but not quite V. at Helston, Nancegollen, Penrose, Porthleven and Wendron; IV. at

Breage, Budock, Camborne, Gwennap, Gwinear, Gwithian, Hayle, Lannarth, Leedstown, Mabe, Manaccan, Marazion, Mawgan-in-Meneage, Mawnan Swith, Penryn, Perran-ar-Worthal, Phillack, Praze, Redruth and St. Ives; III. at Mullion, Penzance and Truro.

These observations enable us to draw the isoseismal of intensity IV. with some accuracy. The area inclosed by this curve is 20 miles long and 15 miles broad, and contains about 224 square miles. The centre of this area is indicated on the map by the star marked B. The direction of the longer axis is approximately east and west.

Outside this area we have observations from only seven places, and not more than four of these are of much value in determining the boundary of the area over which the earthquake was perceptible. Some guide is however given by the position of several places where the shock was not felt, inquiries having been made from many persons in each place. It is clear that the accuracy of the outer line cannot be depended upon, but it is no doubt sufficiently close to the correct position to support the inferences that will be afterwards made about the origin of the shock. As drawn upon the map, the area enclosed by this line is 29 miles long and 22 miles broad, and, including the part covered by the sea, contains about 480 square miles. The centre of the area is indicated on the map by the star marked C.

Nature of the Earthquake-Phenomena.—Of the accounts given below, the first group come from places lying close to the shorter axis of the disturbed area:—

Helston (Observer, Rev. W. Jeffery).—A distant rumble heard, gradually increasing in intensity until it became a violent thundering sound, at which instant everything in the room was perceptibly shaken, the sound dying away after the shock with the same rumble as before. Duration of shock, two to three seconds.

Redruth.—(1. Observer, Mr. T. Carhart.) Two vibrations, the first the stronger; preceded and followed by tremulous motion; vertical motion perceptible, downward first and then upward. A roaring sound heard, preceding the shock by about five seconds, and ending several seconds after it. Duration of the shock, about four seconds.—(2. Observer, Mr. W. K. Wilton). A continued trembling, consisting of several vibrations, the strongest shortly after the first, then dying away; direction, apparently from the south-west; duration, less than ten seconds. A sound like that of an explosion in a distant part of a mine but more prolonged.

The next three places are close to the longer axis of the disturbed area, the first two near the eastern end:—

Penryn (Observer, Mr. J. Blamey, M.R.C.S.).—Two distinct vibrations of equal intensity, each accompanied and followed, but not preceded, by a tremulous motion. Each vibration also was accompanied by a sound of the same kind and intensity, like the crash of a heavy weight on the floor above, and followed by a rumbling sound like that of a waggon roaring along the street, continuing after the tremulous motion and dying away in the distance. Duration of shock, three or four seconds.

Budock (Observer, Mr. R. Mollett, awakened by the earthquake). —The sound like that of an explosion at some distance, followed by a distant rumbling sound lasting about 30 seconds.

St. Ives (Observer, Rev. J. Balmer Jones).—A tremulous motion, half felt, half heard, lasting perhaps nearly half a minute; and then, the shock, like the sliding fall of a mass of slates on the roof, but much heavier, lasting less than five seconds, the house left vibrating afterwards. The sound like that of a heavy waggon driven rapidly over a rough granite pavement, or like the rapid approach of a hurricane gust; the beginning preceded that of the principal vibrations by more than 15 seconds; it became gradually louder, the shock coming like a great blow when the roaring sound was at its highest, and then the sound died away like the vibration of a great bell, the end following that of the shock by about 15 seconds.

The above places are all within the isoseismal of intensity IV. Inside this line, the nature of the earthquake, though variable to some extent, may be summed up as follows: a tremulous motion, accompanied by a rumbling sound, increasing in intensity until the principal vibrations and a sudden sound (as of an explosion) were perceived simultaneously, followed by a tremor and sound which gradually died away. At some places, two vibrations, each accompanied by an explosive sound, were observed, as at Redruth and Penryn mentioned above. This was also the case at Breage and Perran-ar-Worthal.

Outside the isoseismal of intensity IV., the sound-phenomena became relatively more prominent, the shock being felt either very slightly or not at all. At St. Keverne, Mr. E. J. Leverton-Spry (who was awakened by the sound) felt no shock, but heard two or three sounds like knocks at the front door. With this very interesting account may be compared the following record from Phillack, a place on the opposite side of the epicentrum but several miles nearer it. The observer was in the open air, standing, and felt no shock, but the sound resembled that of successive discharges of cannon, about six in number and of equal intensity, lasting about three or four seconds. The significance of these observations will be pointed out when discussing the origin of the earthquake.

Time-relations of the Shock and Sound.—These relations have an important bearing on the origin of the shocks, and I endeavoured in my inquiries to direct particular attention to them. Unfortunately, a large proportion of the observers (about one-third) were awakened by the shock, and consequently the initial phenomena were lost to them.

The beginning of the sound is said to have preceded that of the shock at Camborne, Cury, Gwennap, Helston, Manaccan, Mullion, Nancegollen, Porthleven, Redruth, St. Ives, St. Martin and St. Stythians; coincided with it at Marazion, Mawgan-in-Meneage and Penzance; and followed it (immediately) at Gwinear.

The end of the sound is said to have preceded that of the shock at Manaccan; coincided with it at Cury, Lannarth, Marazion, Mawgan-in-Meneage and Penzance; and followed it at Gwennap, Gwithian, Hayle, Helston, Penryn, Redruth, St. Ives, and St. Stythians.

It will be seen from the map that, all over the disturbed area, the beginning of the sound preceded that of the shock and the end of the sound followed that of the shock, the exceptions occurring chiefly at places at some distance from the epicentrum and where the slighter vibrations would be less perceptible.

Origin of the Shocks.—The disturbed area of the first shock is approximately circular. This, in the case of so slight a shock, shows that its seismic focus was of small dimensions.

The focus of the second shock must have been of some magnitude. This is indicated by its elongated disturbed area, and perhaps also by the long duration of the shock. Assuming it to have been fault-formed, the direction of the fault in the neighbourhood of the epicentrum must be parallel or nearly so to the longer axis of the disturbed area, *i.e.* must be about east and west. The intensity of the shock was greatest at Helston, Nancegollen, Penrose, Porthleven and Wendron, all lying to the south of the longer axis of the disturbed area. Now, the intensity of a shock should be a maximum near the point where the normal to the seismic focus through its centre meets the surface. The fault must therefore hade towards the south, and consequently the fault-line must lie on the north side of the epicentrum. This inference is corroborated by the relation which the outer line bounding the sound-area and the area over which the shock was very slightly felt bears to the isoseismal line of intensity IV. The distance between these two lines is greater on the north side than on the south; and, since the sound-vibrations proceed chiefly from the upper and lateral margins of the slip-area or seismic focus, it follows that the upper margin must be on the north side of the epicentrum; in other words, that the fault hades towards the south. Since the centre (C) of the area bounded by the outer line is vertically above a point within the upper margin of the focus, the line of fault must be a short distance, probably not more than a mile or so, to the north of this point. The line D D on the map represents a probable position of the fault-line, but it may be in error by as much as half a mile either to the north or south.

Having thus ascertained the position and hade of the fault, at any rate approximately, we may now consider the nature of the displacement or fault-slip which produced the earthquakes. In the first place, the line joining the two epicentral points is parallel to the fault-line, and therefore the centres of intensity of the two foci must have been at about the same depth. The horizontal length of the first focus, as we have seen, was probably short. That of the second must have been several miles. We have no means of determining it accurately; but, in a case like this, we cannot be far wrong in taking it as the difference between the lengths of the two axes of the disturbed area. For the isoseismal of intensity IV., this difference is five miles; for the outer line it is seven miles. Again, the estimates of the duration of the shock and sound at Budock and St. Ives, places close to the longer axis of the disturbed area, show that the length of the seismic focus must be reckoned in miles. This is all that can be said, for estimates of duration are generally too great, and we are ignorant of the velocity of the earth-wave in the case of a slight earthquake. Also the process of slipping may have occupied an appreciable time. But the two classes of evidence do not conflict. For a distance, therefore, of about 2½ miles on either side of the epicentrum B, the slip may have been comparatively great; and then it must have gradually died away in either direction until it became imperceptible. These lateral margins of the focus cannot have been much under a mile in horizontal length, and they were probably more, especially towards the west.

On this point, some important evidence is given by the observations made at Penryn, Budock, St. Ives and other places, especially those near the longer axis of the disturbed area. Though the precursory sound was observed at most places, it is clear that at those near the east end of the area the tremors and sound were chiefly perceived, or perceived for a longer time, *after* the shock ; and *before* the shock at places near the west end. This shows that the slip died out more gradually towards the west than towards the east.

It is curious that records of the double vibration, or rather double character, of the second shock, come from only four places, namely, Redruth, Perran-ar-Worthal, Penryn and Breage. I believe, however, that the absence of other records is accidental, for few observers perceive or record changes in the intensity. Now a double shock may be due (1) to the focus consisting of two detached, or practically detached, portions ; (2) possibly to the partial reflexion of the earth-wave; or (3) to a repetition of the original impulse. The distribution of the four places mentioned above favours the latter interpretation, the first vibration being slightly more intense than the second. It is clear, too, from the observations recorded at St. Keverne and Phillack, that the amount of slip varied somewhat irregularly over the focus, giving rise to several maxima of sound-intensity, the feebler sound between the maxima not being perceptible to the observers at these places.

Lastly, the simple character of the shock renders observations on the first direction of the vertical motion more reliable than usual. At Redruth, on the upthrow side of the fault, the movement is said to have been first downward and then upward. At Manaccan, on the downthrow side, it was first upward and then downward, and this, I am informed by the Rev. A. R. Eager, D.D., is attested by the evidence of several observers. This shows that the slip of the downthrow side must have been relatively downwards, thus increasing the throw of the fault.

We may now sum up as follows. For some time the strain along this fault had been increasing. Either, however, the strain or the resistance to it was not equally distributed, and first a slight slip took place at 10·30 p.m. on May 16. This had the effect of equalising the strain or the resistance to it, and, consequently, three hours later, a second and double slip took place over a much greater length of fault to the westward, the slip-area reaching to, and perhaps including, that of the first shock; its eastern lateral margin being shorter than the western owing to that shock having previously relieved the strain.

I am not aware that any fault has been traced by purely geological evidence in the position indicated above. But I have little doubt as to its existence there. Moreover, the direction and hade of the suggested fault are in accordance with the known geological structure of the district. It would seem indeed that these shocks are indices of the latest of the long series of movements that have produced the English Channel.

Authorities.—Six of the records on which the preceding account is founded are taken from the "Falmouth and Penryn Times" for May 21, and I am indebted to the courtesy of the Editors of this newspaper and also of the "Western Morning News" (Plymouth) for inserting letters from me asking for observations on the shocks. For other records I have to thank: Breage, Mrs. Nicholas; Budock, Mr. R. L. Mollett; Constantine, Mr. J. V. Albert, M.R.C.S.; Cury, Mrs. J. Bowden; Gwithian, Mr. W. T. Richards; Gwennap. Rev. Canon Rogers; Gwinear, Rev. A. J. Perry; Hayle, Mr. W. F. Cleaver and Mr. J. Vivian; Helston, Rev. W. J. Jeffery and Mrs. Tyacke; Lannarth, Mrs. Shaw; Mabe, Mr. J. E. James; Manaccan, Rev. A. R. Eager, D.D., and Mr. W. Smith; Marazion, Mr. F. Millett; Mawgan-in-Meneage, Mrs. Crocker and Rev. H. L. Wright; Mawnan Smith, Mr. W. Borlase; Mullion, Rev. T. H. Scholefield; Nancegollen, Mr. P. B. Hancock; Penryn, Mr. J. Blamey, M.R.C.S.; Penzance, Mr. A. Craig and Mr. J. Morrish; Perran-ar-Worthal, Rev. H. M. Harmer and Mrs. Rudge; Phillack, Rev. F. Hockin; Praze, Mr. W. Pearce; Redruth, Rev. J. W. Lane and Mr. T. Carhart; St. Ives, Rev. J. Balmer Jones, M.A.; St. Keverne, Mr. E. J. Leverton-Spry; St. Stythians, Mrs. Wesley Andrew; Truro, Mr. H. Crowther; Wendron, Rev. F. T. C. Margetts.

III.—THE CONDITION OF THE ARCTIC LANDS IN THE SO-CALLED GLACIAL AGE.

By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S.

IN my recently published book on the "Glacial Nightmare" I have tried, among other things, to show that the traces of glacial action in the northern hemisphere, instead of being circumpolar, are in fact limited to one half only of the hemisphere, namely, that bounded on the East by the White Sea and on the West by the river Mackenzie. This conclusion is of course not new, and I have merely collected and condensed the evidence of many witnesses to it. I have further suggested as possible, that while Scandinavia, Finland, and the British Islands were the homes of very large and extensive glaciers, the lands now occupying the Polar Sea were in a very different condition, and anything but the homes of widespread ice action.

Before I prosecute the issues further, which you have allowed me to raise in the Geological Magazine, I should like to devote a short space to this interesting and important subject.

To begin with Iceland, the Mountains of Iceland when free from snow seem to me to unmistakably prove that there never was there what it is most patent there was in Scotland and Norway, namely, a great mass of ice occupying the high ground and polishing and smoothing the surface. The contour of the mountains is ragged and torn and splintered, and in some places, such as Allmanna-Gia, it is cut into the most fantastic shapes with projecting pinnacles.

Again, the many blocks of stone found there on the surface of the rocks are not strangers and true erratics, but are all natives. Again, as Mr. Baring Gould, who has travelled much there and has written a graphic account of the Island, says: There are no traces of moraines there except at the skirts of modern glaciers, and he adds that only in one spot had he found unmistakable glacial grooving, namely, along the hill above Bjarg in Mith fjord, and he points out that what are really the results of the action of flowing water in polishing the surface had been mistaken by some for the action of ice. Thus in describing the so-called heithis or fell lands the same writer says: "These heithies, being exposed to the action of snow water, are much torn and mangled, the rock being, in many places, quite polished by the streams from the thawed snows, as they slide over them. Mr. Chambers, in passing this same tract of moor from a different direction, saw similar polishings, and at once put them down to glacial action, and the furrows caused by the little rills to the striæ of glacial grooving. I believe him to have been mistaken, for the following reasons: the rock is not smoothed except where the streams flow over it, and a slight node of rock three inches high is quite sufficient to divert the stria and alter the direction of the polished surface. A considerable removal of earth had taken place this spring, and I observed no marks of glacial smoothing on the rock upon which the soil had rested; it was ribbed and curdled like ordinary lava" (Iceland, its Scenes and Sagas, p. 63.)

Again, turning from the mainland of Iceland to the islets and rocks which surround it the evidence is the same. These islets stand up in the form of splintered pinnacles and needles and form the best possible evidence that ice cannot have smothered and smoothed them as it did the Scottish isles. Thus the same writer says: "Rock-needles, which abound on the coasts, are named Drángir by the natives. Some of these are very noble. The entrance of the Isa-fjord is guarded by one such, standing up from a platform of basalt high above the water; it goes by the name of the 'Sentinel.' A curious spire of rock above the Hörgárdalr is illustrated on plate xi. There are needles in the Skaga-fjord off Drangey, and in the Breithi-fjord" (*id.* p. xxix.). The existence of these pinnacles and sharp angled rocks is inconsistent with the former existence of a great glacial covering.

Lastly, the flora and the fauna of Iceland cannot, it seems to me, be explained by any other theory than that they are the shrunken relics of what was once richer, and that instead of pointing to the former presence of a glacial climate, they point rather to the climate being now more severe than it has ever been since this fauna and flora occupied the island.

That the climate of Iceland has been getting more severe was long ago suggested by the famous traveller Henderson. *Inter alia* he says: "It is evident, from ancient Icelandic documents, that on the arrival of the Norwegians, and for several centuries afterwards, pretty extensives forests grew in different parts of the island, and furnished the inhabitants with wood both for domestic and nautical purposes. Owing, however, to their improvident treatment of them, and the increased severity of the climate, they have almost entirely disappeared."

Elsewhere we read—"In the Middle ages the S.W. parts of the island were covered with forests, and the old sagas report, without attributing anything extraordinary to the fact, that the house and boat builders went to cut logs in the adjacent forests" (Suarfdvela Saga. A. Geffroy, Revue des Deux Mondes, 1st Nov. 1875). "Ollafsson and Pälsson, who themselves saw a tree 12 metres high, heard speak of a ship built of oak which was launched in the Hval Fjördr north of Reykjavik, and thence went to Norway. These travellers in their travels found numerous iron forges, and it was probably the forgers who destroyed the forests" (Reclus IV. 925).

Mr. Watts in his well-known journey across the Vatna Jökull tells us that in passing through woods of birch and willow on the banks of the Gravalanda, he noticed that the largest wood was dead. The important fact for us to remember is that the trees will no longer live there, and are thus in the same position as the pigs, which abounded in the Middle Ages, but which are now very scarce.

The direct evidence again of the glaciers is strongly in favour of their growth in recent times and against their having shrunk.

Mr. Watts says: "When we inspect the glaciers which fringe the south of the Vatna Jökull, we find that they have decidedly advanced; indeed at one point so much so as to almost destroy communication along that part of the south shore. Upon the north we find that a huge tongue of glacier has flowed down full ten or twelve miles beyond the utmost limit assigned to it by Gunlaugson some forty years ago, while the route traversed by that enterprizing man is completely overrun by the ice, and the traditionary road of the Vatna Jökull's verge is now among the high snows of the Vatna" (Across the Vatna Jökull, p. 190).

True, the glaciers of Iceland may, and no doubt do, ebb and flow, but they gain upon the whole, and never would increase to this extent were not the annual accumulation vastly in excess of the waste, and he goes on to urge that the fact is not peculiar to Iceland but has also been noticed in Greenland and Spitzbergen, and says this seems to point to something more than a local advance compensated for by a retreat in other places. It is too rapid an advance to be accounted for by astronomical causes. He goes on to suggest that the Gulf Stream may be shifting, and says it is rather a curious fact that less American drift wood has been brought to the northern shores of Iceland during late years, and an increased amount has been cast on its southern shores (*id.* pp. 191–193).

The evidence then is very strong and very concurrent against Iceland having shared in the so-called glacial conditions which marked Scandinavia and Britain.

Let us now turn to Greenland. Greenland is now so overwhelmed with ice that even if it had had a former so-called glacial period we should not be easily able to disentangle and separate its traces from those of the Arctic conditions which now prevail there, so that we cannot adduce evidence there of the same kind as we can elsewhere, namely, old polished and striated rocks, boulders, etc.

It is of course very well known that in Greenland there are undoubtedly considerable traces of polishing, scoring, etc., outside the range and reach of the living glaciers. Thus Nordenskiold refers to the extensive rounded, polished and grooved border of land which almost everywhere separates the inland ice from the extreme coast, and he goes on to argue that this points to the comparatively recent retirement of the ice, and he adds, in addition, that none of the numberless small sea basins in North Greenland, in spite of the suitableness of the locality for moss vegetation, have yet become filled with turf even to the depth of a few feet, showing, to use his own words, that the slip of ice-free land is but a child of yesterday. I admit completely Nordenskiold's facts, but I cannot follow his inference. As everyone knows, the coast of Greenland north of a certain latitude is rapidly rising from the sea, and the rounding and polishing and striating of the marginal land was the result not of the action of greatly increased land ice, but of that most effective scraper and polisher—shore ice, acting as it still does on this coast and also on the coast of Labrador.

Now, apart from the smoothing down of this marginal land, I know of no direct evidence in Greenland of a former increased development of ice, but the reverse.

The presence of pinnacles and pillars of rock standing up with a perfectly free space round them, seem here, as in Iceland, to be quite inconsistent with the former existence of an ice-sheet on a much greater scale than now exists. Kane speaks of three pillars of greenstone which he calls "Three Brothers' Turrets." These are situated near Dallas Bay. At Sunny Gorge again, north of 79°, he speaks of a solitary column or minaret tower as sharply finished as if it had been cast for the Place Vendôme; the length of the shaft is 480 feet, rising on a plinth itself 280 feet high, and he named it "Tennyson's Monument."

These would surely have long ago been ground down and swept away if a great mass of ice corresponding to that which we postulate, when we speak of an ice-age, had formerly prevailed in Greenland. The evidence, such as we have it, of tradition and of archæology goes to show that the climate of Greenland has been growing more and more severe within historic times. Its glaciers have undoubtedly been growing and extending over districts where formerly a much more temperate climate prevailed, and notably in the days of the Norwegian Settlement. The ice has in many places encroached upon the dwellings and hunting grounds of the Esquimaux, which are no longer habitable, and the skulls of Musk Sheep, etc., have occurred where these animals can no longer find feeding ground.

Of late years, says Nordenskiold, the rowing of an umiak in Tessiursarsoak has been rendered difficult by ice-blocks fallen from the glacier, which is said not to have been the case formerly; and one of our rowers, Henry Sissarniak, even affirms that he rowed without obstruction seven years ago round an island which now forms a peninsula jutting out from the margin of the inland ice. Many similar examples in North Greenland are adduced, thus for example, the glacier that issues into Bläsedal, near Godhavn, has since the time when Dr. Rink mapped that place advanced much further into the valley; in the fjords around Omenak the ice has advanced considerably within the memory of man; a path, formerly often frequented between Sarfarfik and Sakkak, is now closed by inland ice, etc., etc. A similar case occurs in Jakobshavn. In a word, he says, there can be no doubt that in many parts of North Greenland, the inland ice is certainly gaining ground.

There is no doubt on my mind, says Kane, that at a time within historical and even recent limits the climate of this region (*i.e.* Greenland) was milder than it is now. . . . The stone huts of the natives are found scattered along the line of the bay in spots now so fenced in by ice as to preclude all possibility of hunting and of course of habitation by men who rely on it for subsistence. Tradition points to these as once favourite hunting grounds near open water. At Rensselaer Harbour, called by the natives Annatak, or the Thawing place, we met with huts in quite tolerable preservation, with the stone pedestals still standing which used to sustain the carcases of the captured seals and walruses. Sunny Gorge, and a large indentation in Dallas Bay which bears the Esquimaux name of the Inhabited Place, showed us the remains of a village, surrounded by the bones of seals, walruses and whales, all now cased in ice. (Arctic Explorations I. p. 308–9.) Giesecke noted long ago that the advance of the glaciers at Disco and Noursoak can be noted year by year.

If this be the evidence of more recent times we can supplement it by evidence of another kind. The great sea of inland ice in Greenland is dotted with islets of rock, etc., which are known to the Greenlanders as Nunataks. The unweathered and rugged outlines of these projecting rocks show they have never been smothered by ice, but they are remarkable in another way. Quite a considerable number of plants have been collected from these Nunataks by the Scandinavian naturalists, and as they are isolated and often situated at a long distance from each other, I know of no explanation which will account for this phenomenon except the fact that these Nunataks, instead of having been at no remote time parts of a continuous land surface with a more moderate climate, were smothered in ice and snow, as they must have been, according to the theories current about the condition of Greenland, in the so-called Glacial age. It is quite impossible to suppose that these rocks situated as they are on the ice plateau of Greenland could have got their vegetable and animal life from any occasional waifs and strays.

I may say that the entire fauna and flora of Greenland points the same moral. It cannot have reached it over the sea, and points unmistakably to its being the shrunken and withered relic of a once much richer life and of once much more temperate conditions. The same argument applies to many of the migrating birds which nest in Greenland but come to Britain and further south to winter. We can only explain their presence in Greenland by the theory that its climate was formerly more temperate instead of more rigorous.

What evidence there is therefore from Greenland is distinctly against its having passed through a similiar phase which in Britain and Scandinavia has given rise to the theory of a glacial period.

Let us now turn to Spitzbergen.

Spitzbergen bears in its very name the evidence of the sharply outlined needle-like contour of some of its mountains. In the Journal of William Bernard, the companion of Barentz, who discovered it, we read: "La terre éstoit la plus part rompue, bien hault, et non autre que monts et montaignes agues, parquoy l'apellions Spitzbergen" (Reclus V. p. 257).

Heughlin describes its west coast as a congeries of deep fjords, and the mountains, to use his own words, as "nicht gesonderte Massen mit vielzackigen, spitzigen Gipfeln auftreten" (Petermann's Mittheilungen, 1871, p. 177).

Elsewhere the same writer compares the rugged and fantastic outline of the island with the crenellated outline of a mediæval castle.

This is assuredly quite inconsistent with Spitzbergen having been smothered with ice, as it should have been in the high latitudes where it is placed, if the so-called Glacial age had ever existed there. Let us continue, however.

"Though I had an opportunity," says Nordenskiold, "of examining in several places in Spitzbergen old beds of glaciers surrounded by solid rocks, I have only very seldom met with any rocks polished and furrowed by glaciers; and those were besides situated on the very edge of the sea. Such extensive and highly polished surfaces of rock as are everywhere met with in Scandinavia are not to be found there." (Sketch of the Geol. of Spitzbergen, p. 7, note.)

The presence of polished rocks close to the sea-level in a country which is rising from the waters so rapidly as Spitzbergen, really points there, as in Greenland, not to old glacier action, but to the scoring of recent shore ice, and thus may also be explained the polished surface of the low-lying Dun Islands, and which have probably risen from the sea quite recently.

The débris of Pleistocene marine life, such as it is, points the same lesson, and Nordenskiold distinctly suggests that in the interior of Ice fjord, and at several other places in Spitzbergen, "one meets with indications that the polar tracts were less completely covered with ice during the Glacial era than is usually supposed" (GEOL. MAG. 1875, p. 531).

Nordenskiold says: Our investigations of Spitzbergen throw no light on the transition from the Miocene Period to the Glacial formation of the present time, or on the nature of the animals and plants that lived in the vicinity of the Pole during the Pliocene and the European Glacial periods. We did not there meet with any deposits that might be regarded as a link between the Tertiary strata at Bel Sound and the present age. . . . Torell and Malmgren found on the shores of Hinloopen Sound and Blomstrand, in an especially interesting layer of earth on the shores of Advent Bay, shells of *Mytilus edulis*, which occurs abundantly along the Scandinavian coasts, but no longer inhabits Spitzbergen; at least, the zoologists of the Spitzbergen expeditions were not able to obtain a single living specimen of it in the dredgings undertaken by several boats almost every day during three summers in the Bays and along the coasts of Spitzbergen. Immense numbers of this shell still inhabit the shallows and banks laid bare by the tide at Tromsö and Hammerfest (Sketch of the Geology of Spitzbergen, pp. 52 and 53). This assuredly points to the climate having become more, and not less, severe since these shells were deposited.

Nordenskiold says further, "we may assume from many circumstances that the layers with *Mytilus* at Spitzbergen are a great deal younger than the glacial beds of Scandinavia; *so that these northern tracts would have been comparatively free from ice during this European Glacial Epoch*" (*id.* p. 53).

It seems to me, again, that we cannot account for the fauna and flora of Spitzbergen on any other theory than that we have already applied to Iceland and Greenland, namely, that it marks the shrunken relics of what was once richer.

Again, Nordenskiold points to many circumstances proving that the glaciers in Spitzbergen have, during the last few centuries, not retreated but advanced considerably, as for instance, at Horn Sound. That sound was apparently well known to the Dutch, as an old chart marks two anchorages there. They describe the sound as stretching one of its arms, containing two islands, somewhat northward; but at present this arm is occupied by an immense glacier, and excepting some small rocks there are no islands to be found in the bay. A similar case was noticed by M. Robert at one of the arms of Recherche Bay (Bel Sound), and most likely analogous circumstances very much changed the shape of Stor Fjord, the bottom of which is occupied by an extensive and low glacier stretching in an even slope as far as Mount Chydenius. The large islands which, according to old charts, were situated at the inner extremity of the bay, cannot be the same small islets that are now to be found there; and it seems more probable that Mount Gotland, now encompassed by glaciers, and some other neighbouring mountains, similarly shut up by ice, were at the time the whalers visited them surrounded by water, and identical with those islands which on the old charts are called Sea Horse Island and Seal Island. At Bel Sound I myself witnessed a most striking proof of glaciers, thus descending upon tracts hitherto free from ice. On the north coast of Bel Sound, directly to the east of the large island which separates Van Mijens Bay from the main bay, there existed only a few years ago one of the best harbours in Spitzbergen. The whalers, on their way from the north coast to Stor Fjord, used often to anchor at this harbour in order to hunt reindeer in the neighbouring fertile valleys; and this, too, was one of the first places visited by Professor Torell's Expedition in 1858. . . . During the winter of 1860–1861, the previously insignificant glacier descended upon the lowland and the grave-hillock on the shore, filled up the harbour and extended far into the sea. It now constitutes one of the largest glaciers of Spitzbergen, from which immense blocks of ice constantly fall down so that not even a boat can venture in safety beneath its broken border (Sketch of the Geology of Spitzbergen, pp. 8 and 9).

In the facts which I have collected in this paper I do not profess to have proved an absolutely conclusive case against the extension of a glacial age (other than the one now in progress) to the Arctic lands, but I do claim to have shown that the available evidence points very strongly in that direction, and it seems to me that those who have argued that because there was a large development of ice in the form of glaciers in more temperate regions there must also have been a corresponding development in much higher latitudes, have not only taken for granted what ought to be proved, but have confused the problem of discovering a true explanation of the so-called Glacial age itself. To this latter problem I hope to be allowed to devote a few sentences on another occasion.

IV.—The Growth of the Indian Peninsula.

By Philip Lake, M.A., F.G S.,
Late of the Geological Survey of India.

It is one of the most fascinating of the recreations of a geologist to attempt to reconstruct the physical features of some past period; and though our essays in this direction have not been attended with complete success, and our maps of early epochs bear a striking resemblance to those of Herodotus and Ptolemy, yet these maps have their value and they are at least steps towards one of the goals of the science of geology.

But great though the value of a good map of some past period may be, its interest lies not so much in itself as in its relations to those of earlier and later periods. We wish to see how the geography of one period grew out of that of the preceding.

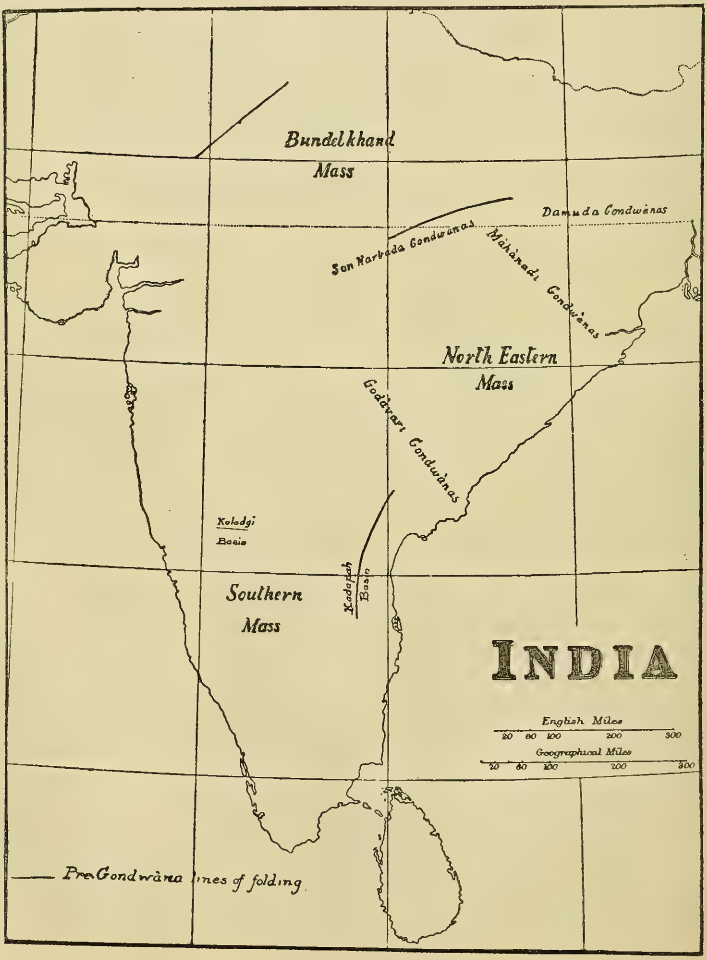
In some areas the geographical changes have been so numerous and so various that this is practically impossible; but in others the changes have been simpler, and we are able to trace with more or less certainty the evolution of the present geographical features.

The Peninsula of India is a case in point. Its growth—not from one, but from three centres—appears to have been nearly continuous; and the present peninsula has been formed by the final union of these three masses. Only along the western coast does there appear to have been any serious interference with the general plan of growth; for the complete absence of anything but gneiss, trap, and very late Tertiary beds on this coast, except in the north, seems to suggest that the coast itself is of very recent formation.

For our present purposes the rocks of the Peninsula, under which term is included the whole of India south of the Indo-Gangetic plain, may be divided into three great divisions, viz.:—

Post-Gondwàna.
Gondwàna.
Pre-Gondwàna.

The Pre-Gondwàna division includes the Gneissic, Dharwar, "Transition," and Vindhyan series, and as fossils are absolutely unknown, we are unable to correlate these series with European rocks. The Gondwàna formation probably ranges from Upper Carboniferous to Tithonian or Portlandian; and the Post-Gondwàna, which includes the marine beds of the coasts, the Deccan Trap, and the Tertiary and later beds, ranges from Upper Jurassic to the present day.



On the map accompanying the Manual of the Geology of India, there may be seen in the Peninsula three main areas of Gneissic rocks:—(1) the Southern Mass, bounded on the north by the Deccan Trap and the rocks of the Godàvari basin; (2) the Bundelkhand Mass, a semicircular mass immediately south of the Gangetic Plain; (3) the North-Eastern Mass, occupying a large area in Bengal and the Central Provinces, and separated from the Southern Mass by the Godàvari area of later beds. The positions of these masses are shown on the accompanying map.

Up to the beginning of the Gondwàna period each of the three masses had its own history, distinct from that of the others, and each must therefore be treated separately.

PRE-GONDWÀNA HISTORY.

Growth of the Southern Mass.—The greater part of India south of the Kistnah is composed of gneissic and granitoid rocks, but it is traversed by a number of nearly parallel bands of schist, together with conglomerates, haematite beds and lava flows, to which has been given the name of Dharwar Series.[1] Many of the schists seem to be altered lavas, and the whole series must have been largely volcanic. The direction of the bands is N.NW.–S.SE.; and it is clear that the Dharwars originally covered the whole, or nearly the whole, of the gneiss, and that they were afterwards thrown into folds running N.NW.–S.SE. (nearly parallel to the present west coast). Afterwards the whole mass was subjected to denudation, so that only remnants of the Dharwars were left, running as bands through the gneiss (see Woodcut-Section, Fig. 1).

The folding and denudation of these rocks were completed before the deposition of the next set of beds, which were laid down as a fringe on the N., N.E. and E. sides of the gneiss mass, forming now the Kaladgi, Godàvari, and Kadapah basins. These basins were probably originally continuous with one another and their present separation is due to denudation.

The Kadapah basin is crescentic in shape and lies on the east side of the gneiss mass. The older ("Kadapah") rocks of this basin in the western part of the area, rest quite flatly on the gneiss

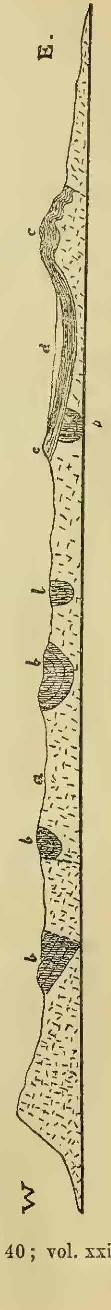


Fig. 1.—Diagramatic Section of the Southern Mass.
a, Gneiss. *b*, Dharwar series. *c*, Kadapah series. *d*, Karnul series.

---

[1] See especially Foote, Rec. Geol. Surv. India, vol. xxi. p. 40; vol. xxii. p. 17. Mr. Foote gives a map of these bands.

or slope gently away towards the east. The higher beds overlap the the lower towards the west; and this, together with the fact that conglomeratic beds are not uncommon, leads one to conclude that the present western boundary of the basin is not far from the old coast-line.

Further east, as the distance from the old coast-line increases, these rocks become more and more folded; and on the eastern side of the basin are frequently reversed. The direction of the folds is nearly N.–S. (Fig. 1).

In the Godàvari basin, which lies to the north of the Kadapah basin, similar beds are found, and here also in the west they are but little disturbed, while further east they are affected by the disturbances which folded the corresponding part of the Kadapah basin.

Hence we may conclude that a series of deposits (the "Kadapah" beds) was laid down on the eastern coast of the gneiss mass; and that ultimately these were crushed up against the gneiss. Near the old coast-line they remained almost undisturbed, whilst further out towards the east they were thrown into a series of N.–S. folds (see accompanying section).

Nearly the same course of events appears to have taken place on the north coast of the old gneiss mass, where we now have the Kaladgi basin of rocks similar to those of the Kadapah basin. The lowest beds, found at the south border of the basin, are conglomeratic, and evidently shore deposits, so that the coast of that time cannot have lain far south of the present boundary of the basin.[1] The beds of the Kaladgi basin have been thrown into folds running W. by N.—E. by S.; and the disturbance is greatest on the N. side of the basin, *i.e.* at the part furthest from the old shore—though this is not so well marked as in the Kadapah basin.

In the Kadapah basin the older (Kadapah) rocks which are affected by the folds already described, are overlaid by later rocks called the Karnuls, which serve to fill up the space between the great folds on the east and the old shore on the west (see section). They are but little disturbed and overlap on to the gneiss.

On the north of the gneiss similar beds are found in the Bhima basin near the Kaladgi basin. Here also they are little disturbed; but their relation to the rocks of the Kaladgi basin is nowhere shown.

After the deposition of these later beds (which are still pre-Gondwàna) the Southern Mass has never received any further deposits, except close to the coasts, and it has remained land since that time.

Growth of the Bundelkhand Mass.—The Bundelkhand gneiss now forms a semicircular patch, bordered on the N.E. by alluvium, and elsewhere chiefly by the well-known Vindhyan rocks.

On the S.SE. border, which runs from E.NE.—W.SW., there is a fringe of quartzites, limestones, etc., known as the Bijàwars. These lie nearly horizontally on the gneiss and towards the south are covered by an extensive spread of Vindhyan beds; but before they disappear they begin to be crushed and folded. They were apparently shallow water deposits and never extended much further north than at present.

---

[1] *Cf.* Foote, Rec. Geol. Surv. India, vol. xv., p. 191, and King, Mem. Geol. Surv. India, vol. viii., pl. ix., section i.

To the south of the Vindhyan spread they reappear in the Son-Narbada and Son areas; where they form a band running parallel to the Bundelkhand Bijàwar band. In the Son area especially they are strongly folded.

Here then again we have a series laid down upon the gneiss and subsequently folded. Close to the gneiss the beds are almost unaffected, while further away they are greatly disturbed.

To the north of the Bundelkhand gneiss we find very much the same thing. Close to the gneiss, at Gwalior, we have almost undisturbed Pre-Vindhyan beds; while further away, in the Arvali Hills, the Pre-Vindhyan beds are strongly folded, the folds running about N.E.-S.W.

Towards the S.W. the Bundelkhand gneiss disappears beneath Vindhyan beds and the Deccan Trap; but at intervals we find inliers of Bijàwars and similar rocks resting on gneiss, in the Dhar Forest, and at Narsingpur, Champanir, Bagh and Jobat.

If the beds at Bijàwar and Gwalior are really shore deposits, close to the old coast-line, it is clear that the Bundelkhand Mass had a history very similar to that of the Southern Mass. Beds were laid down on its borders and afterwards crushed up against it, the most intense folding being at a considerable distance from the old shore.

In the space between these folds (the folds to the S.E. and the folds to the N.W. [see map] of this gneiss) we now find a large spread of Vindhyan rocks. These are little disturbed and may at one time have covered the whole of the gneiss mass.

Growth of the North-eastern Mass.—In the present state of our knowledge, it is impossible to trace the history of the N.E. Mass, even with the same degree of uncertainty as we have traced that of the others. Large areas are covered by Lower Vindhyan and older rocks, but these have not been examined in detail.

No rocks of later age than Lower Vindhyan are known between the Máhánadi and Godàvari Gondwàna basins; and the area has probably been land since Lower Vindhyan times.

GONDWÀNA HISTORY.

The Pre-Gondwàna history of the Southern and Bundelkhand Masses appears thus to have been nearly the same. Beds were deposited on their borders and afterwards crushed up against the unyielding gneiss. At a considerable distance from the shore this crushing caused intense folding, and no doubt elevation; and the space between the folds and the shore was subsequently filled by later rocks, which overlapped on to the gneiss and, in the case of the Bundelkhand Mass, perhaps covered the whole of the gneiss.

Somewhat in this fashion the three great masses appear to have grown outwards until, at the beginning of the Gondwàna period, only comparatively narrow spaces were left between them; and in these spaces the Gondwàna rocks were deposited. They now form strips between the Southern and North-eastern Masses (Godàvari basin); between the Bundelkhand and North-eastern Masses (Son and Narbada areas); and on the north of the North-eastern Mass (Màhànadi, and perhaps Damuda, Gondwànas).

The complete absence of any trace of Gondwàna or later deposits on the Southern Mass (except near the coasts) and on the rocks of the Bundelkhand area, shows that these areas have been land since Vindhyan times. How much of the North-east Mass was land in Gondwàna times it is difficult to say. In the Godàvari basin, the Lower Gondwànas appear along the S.W. border of the field, while higher beds abut against the N.E. border. This may be due to a fault, or to overlap of the higher beds on the N.E. side. In the former case the Gondwàna rocks extended over the North-east massif beyond their present limits; in the latter case the N.E. border of the basin must be near the original shore.

However this may be, some part of the North-east Mass was probably land in Gondwàna times; and the Gondwàna rocks were deposited in arms of water between this land and the Bundelkhand Mass on the N.W. and the Southern Mass on the S.E. They were also laid down on the northern border of the North-east massif (Màhànadi area, etc.).

The Gondwàna beds appear to be chiefly fluviatile and to have been deposited under much the same conditions as the alluvial deposits of the Indo-Gangetic plain. These Indo-Gangetic deposits, it will be noticed, also fill up the space between two pre-existing land areas.

In this way the deposition of the Gondwànas completed the union of the three elements of the Indian Peninsula. Throughout the whole Peninsula no marine beds of later than Gondwàna age are found except near the coast, and the whole area has been land since that time.

POST-GONDWÀNA HISTORY.

But little now remains to be said. The outflow of the Deccan Trap must have greatly changed the configuration of the surface, and may perhaps have altered the northern part of the west coast; but beyond this it does not appear to have affected the general disposition of land and sea.

The presence of marine Jurassic and Cretaceous beds on the coasts, shows that the whole Peninsula has risen since Gondwàna times.

But the most important alteration is one of which we have only negative, and therefore doubtful, evidence. It will be noticed that up to very recent times no deposits of any kind were laid down on the west side of the Southern Mass, while rocks from the Kadapah period downwards were deposited on its northern and eastern shores. It is, therefore, not unlikely that the present west coast of the Southern Mass was not a coast till late Tertiary times; *i.e.* that the Southern Mass extended far to the S.W. of its present limits—and in this connection it is interesting to note that this would give us the "Lemuria" of Wallace, or Gondwàna land of Suess and Neumayr. In Tertiary times the western part of this land disappeared, and the remaining fragment now forms the southern part of the Indian Peninsula.

V.—The Relative Age of Flints.

By A. J. Jukes Browne, F.G.S.

Mr. G. ABBOTT is quite right in saying (Geol. Mag. for June, p. 275) that much work has yet to be done before we understand the formation of flints, and I would add that the work required must include observations on other siliceous concretions such as chert and cherty nodules of all kinds. It is also unquestionably important that we should, if possible, ascertain whether such concretions were formed contemporaneously with the deposits in which they are now found, or whether they are a sort of separation product formed during the consolidation of the rock after upheaval above the sea.

To Mr. Abbott, as to many observers, the vertical veins of flint so often present in Upper Chalk, and termed by him "tabular flint," prove a stumbling-block. These veins do certainly appear to have been formed during or after the consolidation of the Chalk; but need we on this account proceed to assume that all other flints and cherts are of subsequent growth? Surely it is at least possible that some forms of flint are of contemporaneous origin, while others may be of subsequent date.

Before discussing this difficult question let us clear the ground a little by making a rough classification of flints. Mr. Abbott makes no mention of the horizontal or interbedded floors of flint which are sometimes continuous over many square miles (*e.g.* in Kent and Lincolnshire). These are much more correctly called "tabular flints" than the vein-courses which cut the beds at various oblique angles. No one who examines them could doubt that they are interstratified beds and not infilled cracks, though of course it is open to question whether they were always layers of flint.

Chalk flints may I think be classed under four heads:—

1. Nodular flints.
2. Tabular flints and flint floors.
3. Vein-courses.
4. Paramoudras.

An acquaintance with flints and their different modes of occurrence extending now over more than twenty years has only served to strengthen my belief that flint nodules and tabular flint-floors have been formed while the Chalk was being accumulated. I would not deny that the making of a flint may have been a long and slow process; there may have been a succession of phases and changes before an incipient nodule became a hard and glassy flint, but I think that the whole process must have been accomplished while the superincumbent chalk was still soft chalky ooze, and while it was still saturated with sea-water.

It is, perhaps, not generally known that the flints of the successive zones of the Upper Chalk have special characters of their own. The characters of the flints in a given zone are not exactly the same throughout England, but within certain areas they appear to be constant, and they have been used by Dr. Ch. Barrois and the late

Prof. Hébert as aids in dividing one zone from another. Further observations on this succession of forms of flint, with the view of determining how much dependence can be placed upon them, would be very useful; but the fact of there being differences is unquestionable and is evidence for the contemporaneous origin of the nodules.

The flints with hollow tubular cores and spaces to which Mr. Abbott refers are specially characteristic of the *Micraster coranguinum* zone, and have generally been formed round the bifurcating branches of *Doryderma ramosum* (*Spongia ramosa*, Mantell), not round *Siphonia* stems as he imagines. *Doryderma* was a siliceous (Lithistid) sponge and its subsequent solution has left the flints in the condition which Barrois calls *cariés.*

Now it is clear that in such nodules the flint must have been formed around and attached to the body of the siliceous sponge before its solution, and must have been as hard as it is now when the sponge tissue was dissolved out. The solution is not likely to have been accomplished until after the upheaval of the Chalk, *ergo*, the flint was there before. It is quite true that sometimes the cavities are partially or even wholly filled with subsequently-deposited siliceous matter, but this is usually chalcedony and is quite different from the external flint.

Mr. Abbott's suggestion to account for the supposed absence of flints in the Lower Chalk cannot possibly be accepted. He does not seem to know that what was formerly called "Lower Chalk" is now divided into *Middle* and *Lower* Chalk. Flints are common in the upper part of the Middle Chalk and though they do not occur in the Lower Chalk of the South-east or of the Midlands, they do occur in it and very low down in Devon, Dorset, and Yorkshire.

Mr. Abbott is quite right, however, in saying that flints can be found in every stage of development, and a study of these incomplete flints with the aid of a microscope ought to give us some insight into the manner of their construction. My friend Mr. W. Hill, F.G.S., has for some years been occupied in the study of such flints, and I understand that he intends to publish some of his observations at an early date. He agrees with me in regarding the imperfect flints as cases of arrested development apparently for want of a sufficient supply of silica.

The co-existence of flint and chert with a prevalence of sponge spicules is too frequent to be a mere coincidence. All who have recently studied siliceous nodules, notably Dr. Hinde, Prof. Sollas, and Mr. W. Hill, have connected the formation of the concretions with the occurrence of the siliceous sponges. But as to the details of the processes whereby the silica of the sponges has become concentrated in the siliceous nodules and layers we are at present very much in the dark. More observation and experiment is required before Nature yields up this long-treasured secret; but I can see no good reason why the initial formation of all the siliceous nodules, which occur in limestones, should not have been due to the same causes which have led to the production of calcareous and phosphatic nodules in sands and clays; and in the formation of these it is clear that the decomposition of organic matter has played a prominent part.

Lastly, with regard to the vein-courses, I can confirm Mr. Abbott's observation as to the frequency of two layers, and I agree with his conclusion that they must have been formed in fissures, for I presume he means any kind of fissures, such as open joint-planes, and not necessarily faults. This being so, one would certainly have expected that the microscope would disclose some points of structural difference between the flint of veins and that of nodules. Mr. Hill however assures me that he cannot detect any material difference, and it would seem therefore as if we must admit that true flint can be formed in spaces which have been open cracks. It is quite possible however that the deposition of the silica in these cracks took place as soon as the cracks were opened, that is to say during the first upheaval of the mass and while the occluded sea-water was passing away from it. This water must have contained much silica in solution and the mere relief of pressure by upheaval may have been sufficient to cause precipitation of the dissolved silica, though why true flint and not chalcedony was deposited I am quite unable to explain. Similiar veins sometimes occur in the chert-beds of the Upper Greensand, but the silica in them is always chalcedony.

If the flint-veins were formed after complete upheaval and by deposition from water percolating down from the surface of the land, it is difficult to understand when and under what conditions such water could first of all take up silica and then deposit it as flint. Such water would be much more likely to leave veins of calcite behind it, and calcite crystals do not unfrequently occur in empty shells of *Ananchytes* and *Terebratula* and in the cracks which often occur in the beds of "Chalk Rock."

At the same time I admit that there are veins of flint which seem to have originated after the later disturbances of the Chalk, but the theory above suggested would still apply to such cases if we can assume that the areas in which they occur had not previously been raised above the sea level.

There are also chemical questions which probably a little experiment would answer: imagine a mass of chalk for the first time upheaved above the sea-level, the sea-water with which it was saturated and which probably retained much silica in solution would sink to the parts below sea-level, and rain-water, taking up carbonate of lime, would percolate downward. Now what would happen when the carbonated water came in contact with that containing silica, would not the silica be precipitated?

In this paper I have only dealt with the general aspect of the question; the manner in which flint was formed is undoubtedly a great puzzle, and it will not be solved without much patient investigation. So far as I am aware flints only occur in very pure *chalky*-limestones, such as Cretaceous Chalk and the Portland Limestone; but their occurrence in the latter shows that very deep water was not necessary for their formation.

VI.—New Classifications of the Brachiopoda.

By Agnes Crane.

MR. CHARLES SCHUCHERT, of Newhaven, Conn., U.S.A., has recently published in the "American Geologist" (Vol. xi. No. 3) an important and highly suggestive "Classification of the Brachiopoda," based on the history of the class (Chronogenesis) and the ontogeny of the individual. It embodies the latest results of the remarkable investigations on the Palaeozoic forms of Prof. James Hall and Mr. J. M. Clarke, who have thrown so much light on the evolution of genera among the Brachiopoda in the eighth volume of "The Palæontology of New York" (Part I. Brachiopoda, 1892).

Mr. Schuchert adopts the ordinal system proposed in 1891 by Dr. C. E. Beecher and thus divides the Cuvierian class Brachiopoda into the free and attached valves or *sub-classes Lyopomata* and *Arthropomata* of Owen, and the following sub-orders of Beecher, based on the nature of the pedicle passage and the stages of shell growth. (1) *Atremata,* with a free pedicle; (2) *Neotremata,* with pedicle opening in the ventral valve; and (3) and (4) *Protremata* and *Telotremata,* their modified respective derivatives. Three out of these four sub-orders were represented in the primordial fauna, and genera belonging to the fourth "were in existence in the Trenton period of the Lower Silurian."

In 1877 one hundred and thirty[1] genera of Brachiopoda were recognised and divided by Dall into eighteen, and by Davidson, first into eleven,[2] and subsequently into fourteen family groups. Messrs. Hall and Clarke seemed inclined to abandon family designations altogether and left the consideration of the matter for the second part of their work on the Palæozoic genera (*loc. cit.*). Meanwhile Mr. Schuchert has carefully performed a useful work in tabulating the enormous increase of genera recorded during the last sixteen years. They amount in all to rather more than twice the number, viz., two hundred and seventy-seven genera, which he classifies into forty-seven families, and proceeds to show that thirty-six out of these forty-seven were differentiated during the Palæozoic, that only nine survived in the Mesozoic, while six, or one-eighth of the whole number, are represented in the living faunas of existing oceans.

Twenty-four genera are referred by Schuchert to the order Atremata, the oldest and simplest in structure, from which the Neotremata and Protremata almost simultaneously diverged. In the Telotremata, the most modern and numerous sub-order, he includes no less than one hundred and thirty-eight genera—the half of the whole—and considers these rostrated forms as all directly derived from the Neotremata. *Paterina* is regarded as the most primitive known genus of the order Atremata, which gave rise through the *Trematidae* to the *Neotremata,* while the *Protremata* originated from the Atremata by way of the *Kutorginidae*, "one of the first steps from the inarticulata towards the articulate forms of which *Orthis* can no longer be considered as the prototype, as Hall has recently shown that no true *Orthis* exists in the primordial fauna."

---

[1] "What is a Brachiopod?" Geol. Mag. June, 1877, Decade II. Vol. IV.

[2] General Summary of the "British Fossil Brachiopoda," Palæontographical Society, 1884.

Within the compass of eight and twenty pages Mr. Schuchert has produced a valuable epitome of the life-history of this extensive group of ancient and persistent organisms, a difficult and laborious task. He gives a plate (V.) showing the apparent genesis of the forty-seven families and their geological distribution and a tabular view of the geological range of the two hundred and seventy-seven genera entitled to rank as such in his opinion. Concise explanatory notes add to the value and comprehensibility of the associated textual classification. This combines some of the leading ideas of Von Buch, Eugène Deslongchamps, James Hall, Beecher, Gray, Dall, Waagen and Neumayr with original additions as regards sub-orders, new family and sub-family groups.

Thus, he divides the order PROTREMATA into two new sub-orders: 1. TRULLACEA, derived from *trulla* a scoop, defines the spoon-shaped plate, or spondylium of Hall, which covers the delthyrium in the families *Kutorginidæ, Clitambonitidæ, Pentameridæ* and *Porambonitidæ*. 2. THECACEA, from *theca* a cover, for those forms in which the spondylium is absent and the apical three-cornered fissure or delthyrium is covered in the ventral valve by a single plate—the true deltidium. This includes the families *Billingsellidæ, Strophomenidæ, Thecididæ, Productidæ*, and *Orthidæ*, with allied sub-family groups also as emended. 3. ROSTRACEA, a sub-order of TELOTREMATA is restricted to forms devoid of spondylium "or any calcareous brachial supports, other than freely terminating crura." It therefore includes the families *Rhynchonellidæ* (Gray) and *Eichwaldiidæ*, n.f. (Schuchert).

The following nine new families in all are added: *Paterinidæ, Lingulellidæ, Lingulasmatidæ, Trematidæ, Acrotretidæ, Kutorginidæ, Clitambonitidæ, Billingsellidæ*, and *Eichwaldiidæ*. Some new sub-families are also proposed, and others well-known, raised to the rank of family groups, increase the total to forty-seven in number!

In applying the law of morphogenesis, first defined by Professor Hyatt, to the Brachiopoda, Dr. Beecher adopted much of Hyatt's nomenclature. Mr. Schuchert follows suit, although the etymological deficiencies of many of the terms such as *nepionic, ephebolic, clinatologic*, etc., have been freely criticised by Messrs. S. S. Buckman and F. A. Bather in a recent communication to the Zoologischen Anzeiger (No. 405 and 406, Nov. 1892). As the application of the laws of growth, or the science of Auxology, as Buckman and Bather have happily termed it, is rapidly coming into general use and is likely to develop, it seems a matter of regret that American and European biologists cannot define a set of terms for common use not susceptible of modification and variation by etymological purists of the future. Either the invalidity of recent criticisms should be demonstrated, or the modifications proposed adopted as tending to promote uniformity of nomenclature, and that simplification of knowledge which should be the aim of every true lover of science when combined with strict accuracy of statement and observation. American scientists have produced of late so much sound and original work relating to the individual development and genetic evolution of the Brachiopoda that it is a pity that merely finishing touches in this department should be left to Europeans.

A revision of the families of the loop-bearing Brachiopoda was issued contemporaneously by Dr. Charles E. Beecher[1] to whom Mr. Schuchert expressed his acknowledgments for advice and assistance during the consideration of his new Classification of the Brachiopoda in general, wherein all the Terebratuloids are divided into the three families of the *Terebratulidæ*, *Dyscoliidæ*, and the *Terebratellidæ* grouped in nine sub-families.

Dr. Beecher's revision is simpler in character, as he recognizes only two families and seven sub-families. In the first division, for which he retains Gray's family name of *Terebratulidæ*, he places the *Centronellinæ*, Waagen; *Stringocephalinæ*, Dall; *Terebratulinæ*, Dall; and the *Discolinæ*=the family (*Dyscoliidæ*) of Fischer and Œhlert. This last comprises the recent genera of *Dyscolia*, of which *Terebratulina Wyvillei*, Dav., is the type. *Eucalathis*, type *Terebratula trigona*, Jeffreys, and King's sub-genus *Agulhasia*, of which a single species (*A. Davidsoni*) was dredged off the Cape of Good Hope, thus ranging from the Cretaceous to the recent period. The two former occur living in the Lusitanian and West African "Provinces," and are represented by fossil species in the Pliocene deposits of Sicily. Dr. Beecher considers all the Dyscoloids as degraded forms not representative of the highest development of the family type, and that the adult arm-structure in *Dyscolia* is homologous with early larval features of *Terebratulina*, as described by Morse.

King's family of *Terebratellidæ* is re-established and emended by Beecher, who divides it, however, into three sub-families. The prominent feature in this revision is the confirmation and adoption of the main results of the developmental studies of various species of recent *Waldheimiæ* by Friele, Fischer, and the Œhlerts. The Norwegian conchologist was the first to study the successive metamorphoses of the loop in the Northern forms, long known as *Macandrevia cranium* and *Terebratula* (*W.*) *septigera* of Löven. The French zoologists quite recently announced that the results of their investigations of the development of the Southern forms of the same group now called *Magellania*, *M. venosa*, *M. lenticularis*, etc., indicated divergent lines of development such as would necessitate the division of the recent species into two sections, each characterized by serial differences of gradational metamorphosis and adult features, as well as by important geographical limitations.[2]

---

[1] "Revision of the families of Loop-bearing Brachiopoda;" "The Development of *Terebratalia obsoleta* (Dall)," with three plates, by Charles E. Beecher. Transactions of the Connecticut Academy of Sciences, vol. ix. March, 1893.

[2] Sur l'evolution de l'Appareil brachial de quelques Brachiopodes, *Comptes Rendus*, November, 1892.

These discoveries Dr. Beecher now confirms and emphasizes by dividing *Terebratellidæ* into three well defined families: 1. *Dallininæ*, 2. *Magellaniinæ*, and 3. *Megathyrinæ* (= *Argiopinæ*), comprising adult genera which indicate the larval conditions of both the higher groups, each of which ultimately terminates in a form superior to that of the adult *Terebratallia.*

The first *boreal* sub-family receives its designation from the new genus *Dallina*, in which Dr. Beecher has placed the old familiar form of *Terebratula* (*W. septigera*, Löven), paying a just tribute to the excellent work of Dr. W. H. Dall, the *doyen* of the recent Brachiopodists of America. It would, perhaps, have been more graceful to have renamed this northern species after the Norwegian conchologist who first made known the successive stages of the loop development in the boreal type, and to have associated Dr. Dall's name with the new genus *Terebratalia* founded by Beecher, with *Terebratella transversa*, G. B. Sowerby, as type, for it is with the metamorphoses of the *Terebratellæ* that the American brachiopodists' work is more intimately connected. The genera *Macandrevia*, King; *Dallina*, Beecher; *Eudesia*, King; *Terebratalia*, Beecher; *Trigonesemus*, Koenig; *Lyra*, Cumberland; *Laqueus*, Dall; *Muhlfeldtia*, Bayle; *Kingena*, Dav.; *Ismenia*, King; and *Platidia*, Costa; are placed in the sub-family *Dallininæ* of Beecher.

The second sub-family receives the name of *Magellaniinæ* from the culminating type *Magellania* (*Wald.*)*venosa*, Sol.; and the genera *Terebratella*, D'Orb.; *Magasella*, Dall; *Magas*, Sowerby; *Megerlina*, Deslongchamps; *Bouchardia* and *Kraussina*, Davidson, are included therein.

The third sub-family *Megathyrinæ*, Dall, comprises only the recent *Megathyris* (=*Argiope*) *Cistella*, Gray; *Gwynia*, King; and the Liassic *Zellania*, Moore.

The lower genera in all the sub-families do not complete the series of development, but the higher forms pass through all the successive grades. It would seem therefore that both branches of the *Terebratellidæ* originally sprang from some minute form allied to the insignificant atavistic *Gwynia* of existing oceans and Tertiary deposits. Palæontologists should therefore turn their attention to this small but interesting survival of the ancestral terebratelloid type, which doubtless lived before the Jurassic period, when several well-marked genera were in existence. Exact knowledge of the stage of loop development attained by many of the so-called *Waldheimiæ*, of the old terminology, is still lacking. This department of science lost in Eugène Deslongchamps an enthusiastic and capable investigator, a philosophical student of the living forms, and well acquainted with the genetic distribution and succession of the Jurassic species. His work is evidently known and appreciated in America.

Dr. Beecher considers that the radical stock of the Terebratelloids early branched off in two directions. Changing environments accelerated development and thus genera were prematurely launched on the sea of life, and in their turn perpetuated arrested types of inferior grades of structure, while others again passed up into higher phases before attaining maturity. The result was almost the same in the end, as each branch produced forms with a long free loop characteristic of *Dallina septigera* in the northern oceans and somewhat modified in *Magellania venosa* of the southern oceans.

The Megathyrinae appear to represent the stem from which both branches of the Terebratelloids diverged, and we should not be surprised if the *Centronellinæ* were ultimately found to occupy the same position at the base of the *Terebratulidæ* (*emend.* Beecher). It is to this Palæozoic sub-family that the interesting new genus *Hallina*, which seems to be a mixed type, is referred. It is described as a small articulate shell, rostrate, biconvex, semiplicate with incomplete deltidial plates "and calcified brachial supports comparatively long and in form much as in *Waldheimia*." This is the oldest Terebratuloid known, and is represented by two widely distributed species in the Trenton and Hudson River groups of the Lower Silurian of New York, Iowa, Minnesota, Tennessee, and Kentucky.[1]

Dr. Beecher gives three plates illustrating the individual and genealogical development of the *Terebratellidæ* figuring the gwyniform, cistelliform, bouchardiform, megerliniform, magadiform, magaselliform, terebratelliform, and ultimate magellaniform phase successively assumed by the higher members of the sub-family *Magellaniinæ* of the southern oceans. The gwyniform, cistelliform, platidiform, ismeniform, muhlfeldtiform, terebratelliform, dalliniform grades of the boreal sub-family *Dallininæ* are placed side by side for comparison.

An interesting account is added of the "development of a new form *Terebratalia obsoleta*," Dall, a Californian brachiopod, originally described by Dall as a variety of his *Terebratella occidentalis*; but now, not only admitted to rank as a distinct species, but, according to Beecher, representing an adult stage in the development of *Terebratella* differing so much from the typical *Terebratella dorsata*, Gmelin, that it is given generic rank as *Terebratalia*, Beecher. To this new genus the species, hitherto known as *Terebratella transversa*, *frontalis*, and *coreanica*, are also referred, with *T. transversa*, G. B. Sowerby, as the type.

We were not aware, prior to reading the footnote on p. 383 of Dr. Beecher's paper, that *Megerlina* was a synonym of *Megerlia* (now called *Muhlfeldtia*); but considered that Deslongchamps' name represented a valid sub-genus of *Kraussina*. Indeed, this seems to be the view Dr. Beecher has also taken in the text on p. 380!

Some confusion is excusable. A pocket guide to the synonymy of the Brachiopoda would be useful at this juncture; but, like some of the missionary vocabularies of native South American dialects, it might become obsolete before the generic and specific compilation was completed, for the Brachiopodal nomenclature has been shifted of late with kaleidoscopic rapidity. However, as has been well said by an American writer: "The foolish and the dead alone never change their opinions."[2]

---

[1] "New Brachiopoda from the Trenton and Hudson River groups of Minnesota." By N. H. Winchell and Charles Schuchert (American Geologist), vol. ix. May, 1892.

[2] Lowell.

There can be no doubt that a morphogenetic classification and nomenclature embodying the results of general researches into specific development is a material advance, and that all generic and sub-generic names which define and record either well-characterized phases in actual development, permanently stereotyped as fossil genera, must be recognized as valid. Thus we may hope at last to arrive at the true filiation of the fossil forms and their living descendants.

It is to the investigations of Friele, Eugène Deslongchamps, Dall, Morse, Brooks, Beyer, Beecher, Shipley, Schulgin, Kowalevesky, Lacaze-Duthier, and last but not least to those of Fischer and Daniel and Pauline Œhlert that we owe the great advance of our knowledge of the genealogy of the recent Brachiopoda. We seem to have arrived at a turning-point in the history of the race.

VII.—THE CAUSE OF CRATERIFORM SAND DUNES AND CWMS.

By WILLIAM SHONE, F.G.S.

AT St. Anne's-on-the-Sea, Lancashire, there are a great number of very large sand-hills. They are for the most part crateriform in the centre, from the gyratory movement of the wind in stormy weather. There must be some cause, however, which determines the course of the wind, for its natural action one would suppose should be to carry away dunes by sweeping them before it.

I believe the *initial* cause of crateriform sand dunes is rain. The dunes are so porous that the rain does not run off the outsides but sinks through them, carrying particles of sand with it as it sinks to lower levels. This is especially the case when the base of the sand-hill rests upon quicksand. The internal abstraction of sand is greatest in the centre and least at the sides—hence the formation of a *central initial* cup.

During the wet season in Sept. and Oct., 1892, I had many opportunities of studying such phenomena at St. Anne's-on-the-Sea. In one instance I was fortunate enough to observe one of these rain-made hollows formed. It occupied the centre of a deep crateriformed sand dune. It was forty-eight inches in diameter and twenty inches deep in the middle. The centre of the hollow had reached the quicksand which underlies the base of the sand-hill.

CWMS.

May not the similar action of rain, during a lengthened period of time, account for the origin of Cwms. For instance, the beautiful Cwm which forms the N.W. front of Cader Idris, in the hollow of which lies Llyn-y-Gader. Through the moraine matter which stretches across the Cwm, I have heard beneath the surface the noise of the surplus water of Llyn-y-Gader rushing away. Rain is, I think, the Cwm maker as well as the crateriformed dune maker, and both are the effects of sub-ærial denudation and subterranean erosion acting in unison.

I.—A History of Crustacea—Recent Malacostraca. By the Rev. Thomas R. R. Stebbing, M.A. 8vo. pp. i.–xviii. and 1–446, 19 Plates and 32 Figures in the text. One of the Volumes of the International Scientific Series. (London: Kegan Paul, Trench, Trübner & Co., Limited, Paternoster House, Charing Cross Road, 1893.) Price 5*s*.

THE want of a handy text-book on the Crustacea has long been felt, and the neglect into which this great class had fallen, until the "Challenger" volumes made their appearance, is all the more readily to be understood. Grand, however, as the "Challenger" volumes undoubtedly are, they are far too ponderous to put into one's travelling bag, when going down to the sea-side for a fortnight. Moreover, their price, like that of rubies, is above the heads of most work-a-day people, who are well enough educated in Natural History to enjoy and appreciate a quiet sea-side resort, where, pottering around the shallows and rock-pools along the shore, more joy is to be found, than in promenading in new clothes upon the pier, to listen to the sweetest of bands, and watch the prettiest of the fair sex.

Let us then eschew the gay and giddy throng, and taking the Rev. T. R. R. Stebbing for our guide, literally pocketing him, for he only measures 7¼ inches by 5¼ inches (*the book* of course, not his reverence); let us away to some good spot on the south, west, or east coast, and go a "crabbing" or a "shrimping" and see what comes of it.

"It is not generally known that the species of Crustacea extend to a number of several thousands, and that many of these species people parts of the ocean in enormous swarms. Of some of the groups the general character is familiar to everyone; but there are others of which most persons either know nothing, or have not the least idea that they belong to the Crustacea. The beginner therefore will have provinces of a new world opened to his exploration. There is curiosity to be gratified. The sporting instinct will discover many an unexhausted territory. In the manners and customs of the creatures there is much to afford entertainment, and almost every new observer finds something singular to relate. . . . . Nor need man despair of finding out something for his private and personal benefit while investigating the physiology of a shrimp."

Owing to the limited space at his command, the author has only been able to give us a brief account of the members of one great division of the Crustacea, namely, the *Malacostraca* or *Thoracipoda* (H. Woodw.), the highest sub-class of the whole group; including the Brachyura, the Macrura, the Schizopoda, the Stomapoda, the Cumacea, the Isopoda, and the Amphipoda.

Alas and alackaday! even in this volume, the author had so much to tell, that he came within two pages of the end before reaching the *Amphipoda*. "Chapters," the author tells us, "describing the Gammaridea, the Caprellidea, and the Hyperidea, had already been written, when it appeared that they overflowed the utmost space that could be allowed. As room for them could only be found by an unsatisfactory curtailment of the earlier portions of the work, I have preferred to leave over this last section of the Malacostraca hoping to engage the reader's interest in it at no distant future."

We earnestly trust this aspiration may speedily be realized, for it may not be known to all who take up Mr. Stebbing's volume, that this group—which Jonah-like, he has had to cast overboard at the last moment, at the command of an inexorable publisher, and a procrustean (*International*) rule as to size!—is the particular section of the Crustacea upon which the author himself has expended almost a life's work, and with a monograph on which he has filled three large volumes of the "Challenger Reports," covering 1774 pages of text 4to. and 212 4to. plates; a task which has occupied him almost exclusively for six years, and the figures for which, like those of the present little work, were all *drawn with his own hands!*

Seeing this is so, and that the *Entomostraca*, the *Merostomata*, the *Trilobita*, and the *Anchoracephala* or *Cirripedia* also remain to be described, it is not too much to hope, that the publishers should speedily give us another companion volume to complete the history of this important group.

The Crabs, *Brachyura*, or "Short-tails," represent the highest development of the Crustacean type existing at the present day; that is to say, if we regard what Dana calls "cephalization," or the concentration of nerves and locomotory organs around a common centre, as the height of perfection in this class.

Crabs with short-tails date back in geological time to the Great Oolite (*Prosopon mammillatum* and *Palæinachus longipes*, H. Woodw., being the oldest known forms). They are frequently met with fossil from the Upper Secondary to the present day, when they attain their maximum within the warmer latitudes, being represented by land, freshwater and marine forms in great variety and abundance. Mr. Stebbing devotes about 100 pages to this first section and gives us pictures of some of the more interesting forms.

The author places the Anomoura or Anomala (Hermit Crabs, etc.) at the commencement of the Macroura (Lobsters), but as has been pointed out by Dr. Woodward (Encyclop. Brit. 1877, 9th edition, vol. vi. p. 656), some Anomoura appear to belong to the Brachyura, or short-tailed division (Crabs), as *Lithodes*, *Porcellana*, *Dromia*, *Dorippe*, etc.—whilst others, as *Galathea*, *Munida*, *Paguri*, and *Birgus* favour the long-tailed Macroura (Lobsters). Obviously then the Anomala belong to both Brachyurous and Macrourous types, from which they diverge by reason of some method of concealment which they have adopted, and which has modified the usual and normal structures of the class to which they belong, just as the Cirripedia (in their adult sedentary state) and the numerous parasitic Isopods, Copepods, and Rhizocephala, are modified until all trace of their Crustacean lineaments is lost. As might reasonably be expected, the Macroura, being less highly specialized than the Brachyura, date back much earlier in time, numerous forms referable to the genus *Anthrapalæmon* having been described by Salter, Woodward, Etheridge, and Peach, from the English and Scottish

Coal-measures. Lobsters are well represented by numerous genera and species from the Trias to the present day, when they are found all over the world, both in Freshwater and Salt. Many of the Oolitic forms of *Eryma* must be *closely* related to the living Cray-fish (*Astacus fluviatilis*) of our own rivers and brooks; whilst the Chalk *Clytia Sussexiensis* with its spiny carapace and body-segments is probably represented to-day by the living spiny Australian Crayfish (*Astacus armatus*) of the Murray River.

Of the Schizopoda, one form, *Pygocephalus Cooperi*, from the Coal-measures, probably belongs to this division. *Squilla* may even occur in the Carboniferous formation; but true Squillas certainly are met with in the Solenhofen Limestone, Bavaria, and in the Cretaceous of the Lebanon, Syria.

Passing over the Cumaceæ, we come next to the Isopoda, a group of great importance and vast extent.

In individuals as well as in species the Isopoda may be counted by myriads, and they occupy as scavengers, along with the Amphipoda, a most important place in the economy of nature whether by land or sea.

Isopods occur as far back in time as the Devonian, and they are well represented in Secondary and Tertiary rocks.

If Dr. Woodward is correct in his conjecture that the Isopoda are the modern modified descendants of the ancient Trilobites, for which there is a considerable amount of evidence, then the Isopoda date back their ancestry to Cambrian times, the Trilobita living on to the Carboniferous period.

The Amphipoda so numerous at the present day all the world over, both in freshwater and salt, are comparatively rare as fossils. One form, *Necrogammarus Salweyi*, occurs as far back as the Upper Silurian; *Gampsonyx* is found in the Coal-measures; *Prosoponiscus* in the Permian, and there are several others in Secondary and Tertiary rocks.

But our space, like Mr. Stebbing's, is limited, and we must say adieu to the author, merely observing, that so useful a book as he has produced, *needs*, like good wine, *no bush* to make it attractive. It should form a part of every scientific and reference library, and as it is one of the volumes of the "International Scientific Series," it will go, as a matter of course, far and wide, and find itself in many distant libraries all the world over. It will occupy an honourable place alongside Prof. Huxley's "Cray-fish," and will we trust, become converted, by a happy conjunction of activity on the part of the author and publishers—like one of the *Desmidiaceæ*—into a pair of volumes before another eighteen months has passed away.

II.—SUR LE *CYBIUM* (*ENCHODUS*) *BLEEKERI* DU TERRAIN BRUXELLIEN. BY RAYMOND STORMS. Bull. Soc. Belge Géol. Paléont. Hydrol. Vol. VI. (1892), pp. 3–14, Pl. I.

A WELL-PRESERVED cranium of the Scombroid fish, *Cybium*, was discovered last year by M. Vincent in the Bruxellian formation at Fonteny, near Gemappes, and this forms the subject of

Mr. Storms' memoir, just received. Many years ago teeth from the same formation were described by Dr. T. C. Winkler under the name of *Enchodus Bleekeri*, but further studies led to the belief in 1891 [1] that these fossils were wrongly determined, and would probably prove to belong to the existing genus *Cybium*. The discovery of a new specimen now enables Mr. Storms not only to confirm this revision, but to discuss the affinities of the species. The detailed description of the skull is illustrated by a large, folding plate; and the memoir concludes with a brief synopsis of the known extinct species of *Cybium*. The genus has been discovered in the Eocene of Monte Bolca and the Isle of Sheppey; in the Oligocene of Hesse Darmstadt, in Belgium, and Vienna; and in the Lower Miocene of Chiavon, Italy. *Cybium Bleekeri* must have attained a length of more than a metre, almost equalling in size the existing *C. Commersoni*. Species of the genus are rarely met with in European seas at the present day, its habitat being the warmer regions of the ocean.

A. S. W.

III.—CAVERN RESEARCHES.

1. DIE IRPFELHHÖLE IM BRENZTHALE (WÜRTTEMBERG). By Dr. EBERHARD FRAAS. Zeitschr. deutsch. geol. Gesell. 1893, pp. 1–14 (reprint).
2. LE REPAIRE DE ROC-TRAUCAT (ARIÈGE), ET NOTES SUR DES MÉGACÉROS, CASTORS, HYÈNES, SAIGAS, ET DIVERS RONGEURS QUATERNAIRES DU SUD-OUEST DE LA FRANCE; avec Observations sur le Climat de cette Région à la Fin du Quaternaire. By E. HARLÉ. Comptes Rendus Soc. d'Hist. Nat. Toulouse, 1892 (1893), pp. 1–18 (reprint).

THE caverns of France and Germany are still receiving attention, and the two small pamphlets quoted above make interesting contributions to our knowledge of the Pleistocene fauna discovered in them. After describing the situation and physical characters of the Irpfel cavern in the valley of the Brenz, Dr. Fraas discusses the remains met with in the cave-earth, recording the occurrence of *Hyæna spelæa, Ursus spelæus, Felis spelæa, Canis lupus* var. *spelæus, Canis vulpes, Elephas primigenius, Rhinoceros tichorhinus, Equus caballus, E. asinus, Cervus tarandus, C. giganteus, C. elaphus, Bos priscus, Castor fiber*, bird remains, *Esox*, and flint flakes. Measurements are given of a nearly complete skull of *Hyæna*—the first discovery of the kind in Würtemberg. Two small Bear's teeth are noted as possibly referable to *Ursus tarandus*, Fraas (=*U. arctoides*, Bl.); and the determination of *E. asinus* is based upon some very small teeth and a metatarsus. Coprolites are abundant, and the cavern was evidently at one period a Hyæna den. Dr. Fraas concludes that there can be no longer any doubt as to the contemporaneity in Würtemberg of Man and the Reindeer with the Mammoth, Rhinoceros, Cave Hyæna, and other animals he has discovered.

---

[1] Smith Woodward, GEOL. MAG. [3] Vol. VIII. p. 109.

Monsieur Harlé's paper on the cavern and other Pleistocene deposits in south-west France, comprises several short notes read at different dates. The Megaceros (*Cervus giganteus*) is recorded from many localities, but merely on the evidence of jaws, no antlers having been observed. The Beaver only occurs rarely, and very few remains are earlier than the "Magdalenian" period. The common Cave Hyæna is met with abundantly; but M. Harlé has been unable to recognize the Striped Hyæna. Remains of the Saiga Antelope are known from twelve localities. The rodents comprise lemmings, marmots, and *Alactaga jaculus*, Pall. — typical steppe-animals. On the whole, the region north of the Garonne appears to have been a great steppe in the "Solutrian" and "Magdalenian" periods, becoming more humid before the last-named stage of human civilization had passed away. A. S. W.

IV.—PRELIMINARY NOTICES OF THE FOSSIL BONES OF ULLOMA. [Noticias Preliminares sobre los Huesos Fósiles de Ulloma.] By Dr. R. A. PHILIPPI. Annales de la Universidad de Chile, 1893, pp. 499–506, pls. i.–iii.

THESE are preliminary notes on some Mammalian bones from Ulloma in Bolivia. An equine mandibular ramus is referred to *Hippidion nanum*, Burm., and another is believed to represent a new species of the same genus. The remains of *Mastodon*, *Megatherium*, and *Scelidotherium* (?) are briefly discussed, with three plates of outline figures.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—May 10th, 1893.[1]—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

2. "The Llandovery and Associated Rocks of the Neighbourhood of Corwen." By Philip Lake, Esq., M.A., F.G.S., and Theo. T. Groom, Esq., B.Sc., F.G.S.

The area described forms part of the northern slope of the Berwyn Hills, and stretches along the southern bank of the Dee from Corwen to Pen-y-glog. The beds of the Berwyns are here thrown into a series of folds which run nearly E.–W.; and the northerly limbs of these folds are long and low, while the southerly limbs are short and steep. The folds are cut through by a number of faults which run nearly E.–W., generally along the crests of the anticlinals, and these invariably throw down towards the north. The southern bank of the Dee Valley is here formed by these faults.

A second series of faults running about 20° W. of N. to 20° E. of S. is of later date. One of these, near Corwen, presents some peculiar features, since its downthrow in some places is on the east and in others on the west.

The lowest beds present are bluish slates with numerous Bala fossils. These are succeeded immediately by the Corwen Grit of

---

[1] Continued from the June Number.

Prof. Hughes. No fossils have been found in this at Corwen; but in a grit occupying a similar position at Glyn Ceiriog numerous fossils have been discovered. The Corwen grit is succeeded by grey slates with grit-bands; and in Nant Cawrddu near Corwen, and Nant Llechog near Pen-y-glog, these slates are followed by banded black shales containing numerous graptolites of the *Monograptus gregarius*-zone. Above these are pale bluish slates; and nothing further is exposed till we reach the Tarannons. The Corwen Grit clearly forms the base of the Llandovery in this area, as suggested by Prof. Hughes.

II.—May 24th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Notes on Dartmoor." By Lieut.-General C. A. McMahon, F.G.S.

The author alludes to Part II. of a memoir on the British Culm Measures recently published by Mr. Ussher, F.G.S., in which the view is advanced that the granite of Dartmoor resulted from the metamorphism of pre-existing rocks which had in a rigid state offered obstruction to a long sustained N. and S. squeeze, and that their fusion and consequent consolidation were effected *in situ*.

The author gives some of the results of a visit to the western borders of Dartmoor. He details some examples of eruptive granite-veins intruding into Culm beds in the immediate vicinity of the main mass of granite. The latter, in the locality described, is porphyritic down to its boundary, and the veins are also porphyritic. All the circumstances lead the author to believe that these veins are real apophyses from the main mass, and that the view adopted by De la Beche regarding the origin of the Dartmoor granite is the true one. The author alludes to some features in the Meldon granite-dyke not before noted; gives some detailed observations in the bed of the River Tavey, and offers an explanation of the way he thinks the fine-grained marginal variety of the granite, seen in that locality, has been produced.

The author comments on the improbability that a tremendous squeeze sufficient to fuse 225 square miles of a pre-Devonian rock into granite should have left the Culm Measures outside the zone of marginal contact-metamorphism almost untouched.

The author, in conclusion, alludes to the often-observed pseudo-stratification of the Dartmoor granite, and urges that the cause of this is not the one suggested by De la Beche, but that it is due to sub-aerial agencies.

2. "On some Recent Borings through the Lower Cretaceous Strata in East Lincolnshire." By A. J. Jukes-Browne, Esq., B.A., F.G.S.

The borings described in this paper are at Alford, Willoughby, and Skegness, and disclose the existence of an unsuspected anticlinal axis bringing up Lower Cretaceous rocks beneath the Drift. In the Willoughby boring, beneath the Drift, a brown sand was obtained, apparently the 'Roach' division of the Lower Cretaceous, and below it the Tealby Clays (108 feet), oolitic ferruginous beds (18 feet), and sandstone and sand regarded as the Spilsby Sandstone. In the Alford boring the highest solid rock appears to belong to the basal beds of the Red Chalk, and below it is Carstone, and then clay.

The axis of the anticlinal appears to pass between Alford and the border of the Wolds, and is probably continued in a north-westerly direction beyond the village of Claythorpe.

The result of the information now obtained makes it probable that the Chalk tract which lies to the south-east of the Calceby valley is completely isolated from the rest of the Chalk area.

III.—The Geologists' Association.

Excursions Around Bath.

The Whitsuntide excursion of the Geologists' Association, London, commenced on Saturday, 20th May, the rendezvous for the present tour being Bath, Bradford-on-Avon, and Westbury. The Members, about thirty-five in number, arrived in the city of Bath from London and were met at the station by the Rev. H. H. Winwood, F.G.S., who accompanied the party through Widcombe to Combe Down. Mr. Horace B. Woodward, F.G.S., H.M.G.S., President of the Association, acted as Director. On the way a small section of the Fuller's Earth formation was examined, while on the top of the hill one of the stone quarries was visited. Here Combe Down stone, a good freestone belonging to the Bath or Great Oolite, so celebrated in the district, was seen to advantage. The President remarked on the variability of the stone-beds, both in thickness and character as they are traced from one locality to another. In most places the freestone was mined, but here at Combe Down a very durable stone was obtained in open works. Passing on towards Midford, a halt was made at Tucking Mill, once the residence of William Smith, "the Father of English Geology," who was engaged in the construction of the Somersetshire Coal Canal. Through the kindness of Mr. Garrett the Midford Fuller's Earth Works were then examined, and the various processes which the earth undergoes before it becomes marketable were explained. The spots where the earth was dug were next visited, and some fossils were obtained from the hard nodules of earthy limestone that occur in the Fuller's-Earth-clay. The economic Fuller's Earth is an unctuous clay, but it is not plastic like ordinary clay, falling to a powder under water. It owes its peculiar detergent properties to its physical characters rather than to any ingredients it contains; but its particular mode of origin remains to be explained. A number of Ostracoda (tiny bivalved Crustacea) have been found in it. From these works the members proceeded to the road-cutting, south of Midford railway station, and there saw a good section of the Inferior Oolite and underlying Midford Sands. The President pointed out that the Inferior Oolite represented only the upper part of that formation, characterised by *Ammonites Parkinsoni* and *Rhynchonella spinosa*. Many examples of *Trigonia, Ryhnchonella,* and some Corals were obtained. Mr. Winwood pointed out that the lowest bed of the Inferior Oolite contained pebbles of limestone; and this suggested some reconstruction of the strata that marked the interval between the Inferior Oolite and the Midford Sands at this locality. The Midford Sands represented the passage-beds between the Upper Lias and the lower beds of the Inferior Oolite: they yielded *Ammonites radians, A. striatulus,* etc. The members returned to Bath by the 5.37 train.

After dinner at the Fernley Hotel, the President drew attention to some of the geologists who have made Bath famous. He first mentioned John Walcott, whose "Descriptions and Figures of Petrifactions, found in the quarries, gravel-pits, etc., near Bath," was published more than 100 years ago, in 1779. William Smith too was more intimately acquainted with Somersetshire (perhaps Yorkshire excepted) than with any other part of England, and for some time he had resided at Bath. One of his friends, the Rev. Joseph Townsend, rector of Pewsey, had in 1813 first published some of Smith's facts, including accounts of our Oolitic strata and their fossils. Townsend's work was entitled "The Character of Moses established for veracity as an Historian, recording events from the Creation to the Deluge," and the title had naturally somewhat obscured the geological merits of the work. The Rev. J. J. Conybeare, for 11 years rector of Batheaston, was also mentioned, for he did some good geological work, and introduced Sedgwick to his brother, the distinguished W. D. Conybeare, who at one time held a lectureship in the church at Brislington. Talking of Sedgwick called to mind the fact that one of his earliest pupils at Cambridge was the Rev. Leonard Blomefield (then Jenyns)—a man distinguished as a Zoologist, and who also had rendered service to Geology. He attended Sedgwick's lectures so long ago as 1819-20, and had remarked that even then, a year after he had been elected, the Professor "seemed a master of the subject." Passing on to William Lonsdale, some account of his early life was given. He was born in Bath in 1794 and served in the Peninsular War. He was the founder of the Bath Geological Museum and was Honorary Curator from 1826 to 1829, when he went to London. His geological work was referred to as an example of careful and accurate study, and one of his MS. geological maps was exhibited. Mr. Winwood also brought some of his MS. catalogues, which are marvels of neatness. Remarks were also made on Charles Moore, who did so much to elucidate the geology of Somerset, and whose collections of fossils from the Lias and Oolites form so important a feature in the Bath Museum.

On Monday the members of the Association visited Bradford-on-Avon, leaving Bath at 10.18 a.m. There were about 60 members and friends, including Mr. W. H. Hudleston, F.R.S., President of the Geological Society of London), and Mrs. Hudleston, Prof. J. F. Blake and Prof. Lloyd Morgan. The first portion of the programme was under the direction of the Rev. H. H. Winwood, and he conducted the party to the pits by the canal on the south side of

Bradford. There the Great Oolite is overlaid by the Bradford Clay, which at its base contains a rich fossil bed. Among the fossils the most noteworthy were the Bradford Encrinites, portions of which were familiarly known as "Pegtops" and "Coach wheels"—this is an old stone lily. Many Brachiopoda were found, such as *Waldheimia digona* and various *Rhynchonellæ,* also the characteristic *Terebratula coarctata.* Some members of the party went underground in one of the quarries to see the working of the freestone. Other quarries were visited at Ancliffe, and then a general halt was made at the "Three Guns." Proceeding along the north side of the canal, one Norris, a veritable cave-dweller, was visited. This descendant of Palæolithic man dwells in a hollow excavated in the Inferior Oolite, and he devotes himself to the manufacture of eel-baskets, whereby he contrives to support himself, and pay his rent of 1*s.* a year. The party was then conducted to the Winsley quarry, and there Mr. W. H. Wickes took the direction.

After a delightful though warm walk up and down hill the members reached the old quarry of Muirhill, where a rich treat awaited them in the shape of Corals, Polyzoa, and tiny Gasteropoda. The quarry was worked some 70 years ago but has long been abandoned. The fossil beds lie above the freestone, and tumbled masses of the rocks strew the old floor of the quarry. The examination of the place completed the programme. The members then proceeded to Limpley Stoke for tea, before returning to Bath. On the way Mr. Winwood drew attention to the occurrence of the Musk-Ox (*Ovibos moschatus*) in the valley gravel at Freshford, and Mr. H. B. Woodward (president), Professor Lloyd Morgan and Professor Blake made some remarks on the formation of the valley.

On Tuesday morning the members left Bath for Westbury, in Wiltshire, the President, Mr. H. B. Woodward, taking the direction of the party. Fortunately, Mr. Hudleston, F.R.S., was present; and, on arriving at the Westbury Station, Mr. J. R. Tennear, secretary of the Westbury Iron Company, guided the members through the works and explained the processes which the iron-ore undergoes before conversion into pig-iron. The iron-ore occurs at the top of the Corallian beds, and is overlain by the Kimmeridge clay. It is on the same horizon as the ironstone of Abbotsbury, in Dorsetshire. Several fine Ammonites and large numbers of *Ostrea deltoidea* and other fossils were obtained from this ferruginous rock. A fine section of the beds beneath the ironstone was also exposed. This showed a few feet of sand, and then rubbly oolitic and marly beds with *Ammonites plicatilis;* also *Pseudomelania, Bourguetia* (*Phasianella*), and other Gasteropods; *Echinobrissus scutatus,* and a few corals. It was pointed out that this bed probably corresponded with the famous Coral-bed of Steeple-Ashton. Beneath these rubbly beds there was a fine section of false-bedded oolite, quarried for use as a flux in the furnaces. At two o'clock the members witnessed the interesting sight of the flow of the molten iron from one of the blast-furnaces, the fiery stream running in channels or moulds in sand where it solidifies in the form of "pig-iron."

Being detained at the railway station Mr. Hudleston gave some account of the origin of the iron-ore. He pointed out that the occurrence of the large oysters, pectens, and limas, accounted for the presence of phosphoric acid by the decomposition of the animal-matter in those Mollusca. The iron-salts had been introduced into the rocks subsequent to their deposition, and he thought that the decay of fossil wood had been an important factor in the formation of organic acids which had helped to form the carbonate of iron. The iron-carbonate characterised the grey beds that were covered up by the Kimmeridge clay, while the reddish-brown ironstone at the outcrop had subsequently been "rusted." The lower Corallian beds showed little or no signs of ferruginous infiltrations, therefore he thought we must look to the overlying beds for the immediate source of the iron-ore. The members visited other sections in the ironstone; and afterwards walked to the Eden Vale brickyard, where the Gault clay is dug for the manufacture of bricks. The proceedings terminated with an excellent tea at the Lopes Arms at Westbury.—"The Bath Herald." May 27, 1893.

IV.—GLASGOW GEOLOGICAL SOCIETY.

May 25, 1893.—Mr. DUGALD BELL, F.G.S., read the third of a series of papers on "The Alleged Proofs of Submergence in Britain during the Glacial Epoch." In this he treated of the "shell-beds" or shelly-clays in the north of Scotland, at Clava, near Inverness (500 feet O.D.), and on the eastern coast of Aberdeenshire (200 to 300 feet, with gravels considerably higher). Without anticipating the results of the examination of the Clava beds, now in progress by a Committee of the British Association, he was free to state the considerations, founded on what was known a year ago, from which it appeared doubtful whether this clay were really in place, as part of an ancient sea-bottom. All the difficulties which were enumerated in a former paper with regard to Chapelhall, seemed to apply to this bed at Clava also, and some with even greater force. There was the absence of all traces of the sea at a similar level, and at innumerable subordinate levels, over the district generally, and particularly in the numerous side-glens, where such traces would be most likely to accumulate and be preserved. There was the inadequacy of the cause usually assigned for this absence, viz. a "second glaciation," which, if granted, might account for it in some localities, but not in all. To suppose that the ice removed all traces of the sea at such levels over the country generally, was to credit it with far more than ordinary glacialists required of it. Besides, it was cutting away the very ground on which advocates of a "deep submergence" rested. For if this supposed "second glaciation" wrought such havoc among the evidences of the former presence of the sea at such levels over the whole country, where was the certainty that any marine remains now found anywhere at such levels were really in place? They may have been shifted to almost any extent by ice that could do so much. Lastly, there was the remarkable absence of marine organisms, or any traces of them, over the country generally, in the "Upper Boulder-clay," said to have been the product of this "post-submergence glaciation," when the ice must have passed over hundreds of square miles of former sea-bottom. These and similiar difficulties led to the consideration of the hypothesis that the shells, or masses of shelly clay, may have been transported inland from a former sea-bed by the ice, as in many instances which had been proved and were well known. The ice-blocked condition of the North Sea, during the Glacial period, had been demonstrated by Messrs Peach and Horne and the late Dr. Croll, in their admirable papers on the "shelly till" of Caithness. This, combined with the pressure of ice from the adjacent mountainous region of Inverness and Ross-shires, forced the great ice-stream issuing from Loch Ness to turn eastwards, and to some extent upwards, along the base of the hills to the south of Inverness, in the direction of Forres and Elgin. The striæ and the distribution of boulders over the district abundantly proved this; and it was also clear that the ice must have passed over part of the former sea-bed in its progress. Other evidences from that part of the country of the transport inland of materials from the sea-bottom (as fragments of chalk, the limestone near Elgin, etc.) were alluded to; and the author held that, on the whole, till clear proof be obtained, doubts were justified as to this shelly-clay at Clava being really in place. In the concluding part of his paper the author referred to the "red clay," with a few fragments of shells, described by Mr. Jamieson, of Ellon, as occurring in hollows and patches along the north-east of Aberdeenshire up to about 300 feet.[1] For reasons similar and additional to those already stated, he thought this clay could not be accepted as a satisfactory proof of submergence. It could be accounted for by the agencies which Mr. Jamieson had indicated, without submergence; and indeed, its characteristics seemed to be, in several respects, opposed to that theory.

CORRESPONDENCE.

"THE TRUE HORIZON OF THE MAMMOTH."

Sir,—As Sir Henry Howorth asks me to explain some of the remarks that I ventured to make against the cogency of his *foreign* evidence in favour of the pre-Glacial age of the Mammoth, I may premise, contrary to Sir Henry's assumption of my *recent* acquaintance with the subject under discussion, that I have long taken an interest in the many problems that surround the question of the Mammoth and its times, and think that I have read, not without interest and appreciation, most of Sir Henry's writings on this matter, but I must say that the reading has not always brought me to the same conclusions as the author.

I have no pre-conceived views to support and endeavour to bear an open mind on the subject, and most certainly I had no idea of indulging in the dogmatism with which I am charged, for in my innocence, I thought that burden lay heavily on Sir Henry's shoulders.

---

[1] Quar. Jour. Geol. Soc. vol. xxxviii.

Now to the argument,—first comes the evidence of the Lignite beds at Dürnten and Utznach, in which Sir Henry says he cannot quite follow me when I referred to the difficulties of proving the age of the beds by their contained animal remains, consisting of an association and mixture of pre-Glacial and post-Glacial forms of extinct and living species, which can scarcely have been contemporaneous.

Doubtless, the stratigraphical position and assumed age of these Zurich beds was determined by their fossil contents, but the evidence does not appear to me conclusive on this point, and certainly Sir Chas. Lyell speaks much more guardedly than Sir Henry, and Heer himself does not claim a pre-Glacial antiquity for the Mammoth. Professor Heer, summarising the evidence on this question, says (*vide* Heer's Primeval World of Switzerland, Vol. II, p. 217, English Edition), "From the facts hitherto ascertained we learn that the Mammoth appeared in Switzerland at the *end* of the *second* glacial epoch" (the italics are mine).

Moreover, in the Professor's Chronological Table of the Quaternary Period (*op. cit.* p. 203) the true horizon of the Mammoth is evidently undetermined by him, as a point of interrogation is affixed to its first appearance.

Turning now to Sir H. Howorth's strictures on the Russian evidence which I adduced as opposed to his reasoning, and the relevancy of which he says he cannot understand, possibly so, seeing that he is apparently referring to a quite different expedition to the one I cited. The Bear Islands expedition, of which he speaks with that fulness of knowledge so characteristic of him, I never mentioned, as I had no facts before me with regard to it bearing on the question at issue.

If Sir Henry will refer to my paper he will see that it was an expedition to the New Siberian or Liakov Islands of which I was speaking, and which are separated from the Bear Islands by three or four degrees of longitude.

The results of that expedition, so far as regards the Mammoth problem, is only known to the general public through M. Schmidt's brief analysis of Baron Toll's book to which I referred, and which has apparently been ignored by Sir Henry Howorth. Is it too much to ask of Sir Henry to read what he is supposed to be replying to, before indulging in somewhat acrid criticism?

I have a letter from M. Schmidt, who is a member of the Academy of Sciences of St. Petersburg and a foreign correspondent of the London Geological Society, dated in the early part of February last, in which he says Baron Toll's book is not yet fully printed, and that the Baron has left St. Petersburg on another Mammoth quest and will probably be absent about a year.

It is from special explorations such as those of Baron Toll in the so-called "Home of the Mammoth" that its true horizon, so far at least as its Asiatic home, is to be predicated.

According to Baron Toll, and contrary to Sir Henry's assertion, traces of an Ice Age are present in Siberia—beds of fossil and more recent ice, ridges of rolled gravel, the moraine débris of an ancient glacier as seen in the island of Kotelnyi, upon which are said to rest the beds containing the bones and carcases of the Mammoth. Is not this the kind of evidence which Sir H. Howorth is so anxious to secure, and is it not subversive of that assertion of Cuvier that I quoted, and for which Sir Henry reproves me *more suo*?

I have a great respect for such honoured names as Cuvier and D'Archiac, and should think it an injustice to their logical faculties and acumen to presume that their conclusions upon this question would still be the same, notwithstanding that a modified and more natural reading of the evidence was forthcoming than the one that called forth Cuvier's famous dictum.

These are, I think, the principal points of Sir Henry Howorth's rejoinder which call for remark from me, some of the others partaking more of the character of Sir Henry's simile of the Spanish Knight tilting at a figurative windmill, with this difference: that the Spanish Knight is replaced by an English one.

BOWDON, *April* 18*th*, 1893. MARK STIRRUP.

MISCELLANEOUS.

A NEW LEMUROID MAMMAL FROM MADAGASCAR.—There has lately been sent to the British Museum (Nat. Hist.), a large collection of remains of Vertebrates from the South-west coast of Madagascar, comprising bones of *Æpyornis*, remains of *Hippopotamus*, of *Potamochœrus*, sp. of *Crocodilus robustus*, and of two giant tortoises (*Testudo*). Amongst these were discovered a somewhat imperfect Mammalian skull and lower jaw. They were obtained by Mr. J. T. Last, from a marsh at Ambolisatra, beneath a stratum of a white clayey substance (shell-marl) about two feet in thickness. The skull was placed in the hands of Dr. C. J. Forsyth Major, well-known for his researches in the fossil Mammalia of Samos and various European localities, and has been determined by him to be that of a gigantic form of fossil Lemuroid, related to the extinct genus *Adapis* as well as to existing Lemurids. The brain-case is remarkably small in size; the craniofacial angle extremely obtuse, as in most of the lower Mammals. There is an enormous lateral development of the anterior inter-orbital portion of the frontals extending over the small thick-walled orbits, a thick and flattened sagittal, and a strongly developed occipital crest. The Gygomatic arch is high and projects moderately outwards. The thickening (pachyostosis) of all the bones of the skull is very remarkable. The molars and premolars approach closely some Malagasy Lemurids (the canines and incisors are not preserved). Dr. Major names this new form *Megaladapis madagascariensis.*—Proc. Roy. Soc. June 15th, 1893.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. X.

No. VIII.—AUGUST, 1893.

ORIGINAL ARTICLES.

I.—The Rocks of the Volcano of Rhobell Fawr.

By Grenville A. J. Cole, M.R.I.A., F.G.S.
Professor of Geology in the Royal College of Science for Ireland.

THE conclusions as to the stratigraphical relations of the volcano of Rhobell Fawr, north of Dolgelley, in Wales, which were arrived at by Mr. T. H. Holland and myself,[1] have received kindly recognition from Sir Archibald Geikie in his Presidential Address to the Geological Society of London in 1891;[2] and we may now consider that the great ring of Arenig volcanoes, Cader Idris, the Arans, Arenig Fawr, and Moelwyn, rose upon an area already shattered by sporadic Cambrian outbursts. After again visiting Rhobell Fawr in 1892, in company with Mr. Mervyn Marshall, I feel able to give some account of the rocks that build up that volcano and its outlying fort-like masses.

The area, extending some four miles from north to south and two miles from east to west, is coloured generally as "greenstone" on the map of the Geological Survey, which was published in 1855; but it is probably well known that the mass has in reality a complex structure, including a few dykes and lavas, and immense accumulations of tuff and ash. Mr. Clifton Ward wrote,[3] "The rocks of Rhobell-fawr, with the exception of a few small patches of undoubted greenstone, seem to be mainly of volcanic origin. The greatest thickness of beds exposed in a clearly continuous section, from the base on the south side of the summit, consists of alternations of coarse ash, breccia, and slaggy or scoriaceous breccia, with which are mingled in many parts numerous crystals of hornblende, some of them attaining a very large size." Mr. Ward recognized, particularly on account of the prevalence of hornblende crystals, that the material erupted was "of a slightly different nature to that now forming the widely spread felstone and ash-beds of Arenig and Llandeilo age."

I. The Augite-Aphanites.

There are but scanty representatives of the deep-seated rocks of Rhobell, and most of these have cut through the later ashes. Yet they have a general affinity with the fragmental materials of the mountain, setting aside the hornblende crystals that occur so freely in the tuffs. Augite occurs, as we shall see, as the prevalent ferro-magnesian constituent of the massive rocks and also of the scoriæ.

---

[1] "On the Structure and Stratigraphical Relations of Rhobell Fawr," Geol. Mag. 1890, p. 447.

[2] Quart. Journ. Geol. Soc. vol. xlvii. Proceedings, p. 107.

[3] Mem. Geol. Survey of Great Britain, vol. iii. 2nd edit. p. 58.

The augite-aphanites, or dolerites, do not contain olivine, and are the holocrystalline representatives of fairly basic andesites. One of the freshest examples (a third of a mile north-east of the summit of Rhobell Fawr, and across the wall) has a beautiful ophitic structure. The plagioclases, by the test of symmetrical extinctions, prove to be oligoclase, with here and there an albite, and are excellently preserved; but titanic iron ore is freely scattered, and the specific gravity of the mass is 2·89. In the steeply descending enclosed area half a mile south of the summit there is a band of augite-aphanite intersected by abundant veins of compacter material. This mass is more basic, with labradorite and titanic iron ore, and a specific gravity of 2·97. The ophitic structure, so common also in the Cader Idris "greenstones," is again conspicuous; but the later stage of consolidation has been hurried, and the ophitic areas thus lie scattered in a fine-grained groundmass. In fact, it is an unusually striking example of distinct ophitic crystals of augite, which, moreover, are often simply twinned. The included felspars run in from the surrounding groundmass, and hence the ophitic areas were formed *in situ,* and not floated up from a shattered and pre-existing mass.

A third specimen, on the fringe of the area, south-east of Allt-lŵyd farm on the upper Mawddach, is continuously ophitic. Pyrite is developed in it, a characteristic mineral of the whole district.

The intrusive mass to the south of the summit of Moel Cors-y-garnedd is a handsome augite-aphanite with scattered porphyritic pyroxene; its specific gravity is 2·98. It might prove to be another outcrop of the mass that appears in the enclosed area south of Rhobell Fawr.

There are some bosses of compact aphanite, coloured yellow-green by epidote, on the south of the volcano, between the ashes of Bryn Brâs and Garth Fâch; there is a small exposure below the footpath east of the summit of Moel Cors-y-garnedd; and in the valley of the Geirw, between Rhobell Ganol and the north-west spur of Rhobell Fawr, there are three or four places where aphanites come up through the hornblende-ashes or the Lingula Flags. One of these rocks, almost as fine-grained as an andesite, has a specific gravity of 2·98, which is accounted for by the copious development of yellow epidote, one of the commonest minerals in basic igneous rocks throughout N. Wales. These are all the occurrences of undoubtedly holocrystalline rocks with which I am acquainted in this area.

II. The Basaltic Andesites.

There are, however, a number of andesites, some of which are intrusive. They are all somewhat uninteresting to the eye; but they divide themselves on closer examination into augite-andesites of a basaltic character, doubtless once richly dark in colour like those of the Nahe or of Selmeczbánya; and a series of highly felspathic rocks, on the other hand, which I shall class here as Trachytic Andesites. Probably alteration has deepened the original grey tint of many of the latter, and lightened the blackness of many of the former series, intercalating specks of epodite and chlorite, until the whole group of andesites has become monotonously alike.

Some, however, of the more basic series are heavy and compact, and yellow-green through abundant epidote. One of these, on the summit of the picturesque bluff of Graig Fâch, contains soft dark grey pseudomorphs, which seem under the microscope to be after pyroxene. This suggestion is borne out by several blocks gathered from the tuffs, and by the grey-green andesite of the cliff west-north-west of Ty-mynydd-y-newydd, a rock that looks merely like a baked ash in the field. Under the microscope it shows porphyritic augites here and there; but the majority have been reduced to patches of epidote and chlorite. This rock, one of the lowest on the east flank of the volcano, has a specific gravity of 2·95.

Then, among the hornblende tuffs of Rhobell-y-big, a mass of porphyritic augite-andesite occurs, successfully imitating the compacter tuffs to the naked eye. The augite is here in excellent preservation, and is simply twinned; the felspathic constituent, however, is nearly lost. In the groundmass a number of hexagonal pseudomorphs furnish one of those provoking suggestions of nepheline which seem destined to remain nothing better than suggestions. The examination of early Palæozoic lavas is sometimes more irritating than conclusive.

Hard by, south of the fine crest of Rhobell-y-big, we have a grey-green and almost flinty lava with porphyritic augites, many of them entirely replaced by granular epidote. Those that are preserved show a very marked zonal structure, and the invasion of epidote has attacked them in the outermost zones. This rock has a specific gravity of only 2·83.

A scoriaceous lava, one of very few, on the descent to the road south of the summit of Rhobell Fawr, with its cavities full of chlorite, zeolites, calcite, and chalcedony, is basic enough to be referred to this division of the andesites.

Coming farther south, there is an andesite, rich in epidote, at the north-east end of Bryn Brâs; the porphyritic crystals, soft and dark grey, are mere green pseudomorphs under the microscope, with little epidote granules in a chlorite ground; but their cross-sections in the specimen show them to have once been pyroxene.

So far, hornblende does not seem to be a constituent of the basaltic andesites of Rhobell, though occurring freely in the tuffs. But high up on the north-west spur of the mountain, east of Ty-canol, and west of the hollow of the Geirw, there is a broad exposure of scoriaceous lava which contains abundant hornblendes. In the field Mr. Marshall and myself referred it to the hornblende ashes, but fragments of lava were not apparent in the groundmass. The zoning of the hornblendes was the most pronounced feature; and this, under the microscope, is seen to be connected with their alteration. The lava is an amygdaloidal augite-andesite, the porphyritic pyroxenes remaining sufficiently preserved for recognition; but brown hornblendes, 1 cm. or so in length, have been brought up freely with it and form its more obvious porphyritic constituent. As usual, the hot magma has acted on the outer zone of the crystals, and has left only a band of magnetite dots; inside this is a zone in which the colour and pleochroism of the mineral are preserved; and the central area is bleached and fibrous, still retaining enough continuity to show that its extinction agrees with that of the brown zone. Epidote has arisen in this area, and fine needles of almost colourless secondary amphibole penetrate the groundmass of the rock in every direction. The specific gravity of this hornblende-augite-andesite is as high as 2·95.

III. The Trachytic Andesites.

Rhobell Fawr is a complex area of ridges and hollows, stream-cuts, and bolder valleys; and it was not until my third visit that I realized the important part played in the constitution of the volcano by rocks first noted on the extreme east, but having their full development on the passes over to Llanfachreth on the west. These form a series of compact grey rocks resembling phonolites or tephrites in various stages of decay. Coming as I did on this last occasion fresh from the fascinating phonolite domes of N.W. Bohemia, the appearance of these rocks was most attractive, and their detailed study, as usual, disappointing. What felspathoid may have once been present in them, besides the abundant plagioclase, it is now impossible to say. The felspars are largely converted into microcrystalline dusty areas; the porphyritic pyroxenes, preserving their outlines, are often mere patches of calcite. These plagioclastic lavas are unlike the Welsh "felstones" on the one hand, and the heavy basaltic andesites on the other. They have now a pretty uniform specific gravity of 2·75, the more highly silicated eurite of Dduallt, which lies in the Arenig series, giving only 2·60. I have classed these grey rocks of Rhobell together under the Trachytic Andesites, since their common characters, poverty in ferromagnesian constituents and abundance of plagioclase, would certainly carry them into this division.

Wherever I have been able to follow them out, these lavas are intrusive. One of them comes up between ash and slates under Graig Fâch, and has baked the slates beneath it; its specific gravity is 2·74. Another, scoriaceous but intrusive, its hollows filled with chlorite, appears similarly above the slates half a mile to the north north-east of Graig Fâch and south-west of Ty-newydd-y-mynydd. It has a specific gravity of 2·77.

South-west of Graig Fâch, and still at the base of the mountain, we have an intrusion of grey andesite among the slates, which are there well exposed along a steep stream-cut. This mass climbs for some distance towards the greenish ashes of the upper slope, and probably penetrates them, like the rock of Graig Fâch. It contains some pretty pseudomorphs after zoned porphyritic pyroxene.

In the hollow between Moel-Cors-y-garnedd and Rhobell Fawr another and more felspathic mass occurs, possibly a lava contemporaneous with the ashes round it. Its specific gravity is 2·75.

The great area for these puzzling rocks is, however, the high shoulder traversed by two romantic little passes, the Bwlch Goriwared and the Bwlch Gwyn. The latter spot, especially at sunset, is one of the most charming view-points in North Wales. Where the road from the base of Moel Hafod-Owen begins to rise and go over to Llanfachreth, the trachytic andesites come in intrusively among the slates. One can trace them along Foel Cae-poeth, and pick them up again at the Bwlch itself in a tor-like exposure on Moel-y-Llan. A great amount of calcite has arisen in them, and ferromagnesian minerals are hardly traceable. The specific gravity of the rock near Foel Cae-poeth is as low as 2·70.

On Moel-y-Llan the rock contains abundant small crystals of pyrite, which are now often represented by skeletal remains. Decomposition-products, probably the stable oxide limonite, separated out along planes that, from their angles of intersection, seem to be those of the octahedron; consequently we have now the black casts, as it were, of these cracks alone remaining, with a mere amorphous infilling between their intersections to represent the solid crystal. These dark skeletal meshes are certainly formed of planes, not of intersecting rods; and hence the above explanation seems the true one.

Between the two passes, on the hummocky ridge, the flinty andesite weathers white like the Arenig eurites, and is in every way calculated to deceive the observer. On the high boss just west of the Bwlch Goriwared, the greener and softer character reveals itself when the rock is broken, and it has a specific gravity of 2·76. The pseudomorphs in this place point to hornblende as an original porphyritic constituent, which would mark off this example from all the other trachytic andesites of Rhobell. Skeletons of pyrite occur, recognisable only when compared with those of Moel-y-Llan, since the interstices are in this case coloured a pale chlorite-green.

Then, down under the Coed Cwm-yr-Eglwys, close to Llanfachreth, there is a very fine-grained pyritous rock, with a specific gravity of 2·84, probably belonging to this series; but it is so soft and fissile that it has been collected only to be laid aside again. Enough unsatisfactory material has already been described.

IV. The Tuffs and Ashes.

The great remaining masses of the Rhobell Fawr volcano are tuffs and ashes, the former containing in places blocks some 20 cm. across; but the general character, despite the description in the Survey Memoir, is fine-grained in comparison with those of Snowdon or Cader Idris.

On the south the ashes are in general less coarse, and take up the cleavage of the district, as may be noticed in Garth Fâch. Near the summit of Moel Cors-y-garnedd they have been laid out in water, and contain sand-grains and argillaceous bands, passing in places into the grit that caps the hill. Similarly the ashes are gritty under the corresponding bed on Rhobell Fawr,[1] while the grit ("Garth Grit") itself contains pebbles of lava washed down into it.

Coarser tuffs, with unmistakable scoriæ, may be seen from the tumbled moorland below Cerniau, and across the Pabi, away to the crest of Rhobell Fawr. A section cut from one of these scoriæ shows the felspar replaced entirely by epidote and chlorite, and the ferromagnesian constituent represented by mere black skeletons. Its specific gravity is 2·88. In general the tuff has a *purple* tint, and the scoriæ weather away more easily than the tough interstitial ash, which is quite contrary to one's experience on more recent cones. Here the whole mass has been so compressed, consolidated, and mineralized, that the looseness of the ash or the massiveness of the ejected blocks no longer exerts an influence, and the amount of loss by denudation depends mainly on compactness. The vesicular blocks of lava are eaten away, and the surrounding volcanic dust stands out as a meshwork of fine ribs.

The highest rock on Moel Cors-y-garnedd, even above the grit, is a grey highly felspathic ash, with a specific gravity of 2·70. The plagioclases are well preserved, and this bed points to the intrusion and eruption of the trachytic andesites during the last phase of activity on Rhobell Fawr. The slate ash at the base of the Arenig series east of Ty-newydd-y-mynydd is also felspathic, like many on Cader Idris; but there are fragments of glassy lavas in it unlike anything on Rhobell, and it probably marks the next period of activity from a vent further to the east.

There is also ash on Rhobell Fawr above the ring-like exposure of the grit; below, especially to the north and south, we descend over magnificent developments of Hornblende-Tuff.

This rock has at times been styled a "Hornblende-Porphyry"; but the microscope exposes its typically fragmental character. In the wide moorland from which Rhobell Ganol, Moel Gron, and the bold peak of Rhobell-y-big rise, hornblende-tuffs and ashes are everywhere conspicuous, until we find their most striking representatives in Rhobell-y-big itself. A little to the east, down on the nearest tributary of the Mawddach, these deposits may be seen in contact with fossiliferous Lingula Flags. On the whole, they form a basal feature of the volcano, and their coarseness at Rhobell-y-big suggests a local centre of eruption north of the main crater. Possibly the andesite with porphyritic zoned hornblendes, previously described from the N.W. spur of Rhobell, may have acquired its hornblende from these tuffs, which were traversed by it in its ascent.

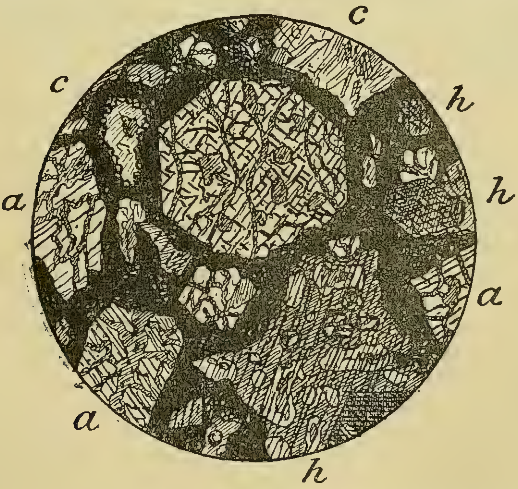
The scoriæ and lumps of lava in the hornblende-tuffs are merely basaltic and trachytic andesites with altered pyroxene, resembling those described above as massive rocks. An ejected block from Rhobell Ganol, containing much epidote, has a specific gravity of 2·96. Small irregular brown hornblendes occur in some of the fragments on the south of Rhobell Fawr; but I find in these fragments as a whole a repetition of the lavas of the area, and the conspicuous crystals of hornblende lie in the ground between them, and are derived from some deep-seated source.

---

[1] See Cole and Holland, "Structure of Rhobell Fawr," Geol. Mag. 1890, pp. 448 and 452.

The conditions that give rise to amphibole being hydrothermal, rather than those that prevail in the ordinary cooling of a lava, it is not necessary to suppose that in this instance an amphibolite has been shattered by the explosions and its remains mingled with the normal lavas; we may conceive that the brown hornblende developed porphyritically as a deep-seated constituent from the local magma, but that augite took its place when the same magma consolidated nearer the surface. In that case, considering the enormous abundance of the crystals, it is remarkable that we so seldom find them included by flotation in the lavas from which they are supposed to have developed. I am inclined to think that a rock rich in amphibole did actually exist beneath this area, perhaps a true amphibolite, and that it was traversed and broken up by the eruptions of basaltic andesite. These eruptions became less uniform in character towards the close of activity, giving us, particularly on the west, the grey trachytic andesites, and in places the handsome ophitic aphanites, which are often of a more basic character.

The amphibole of the tuffs is accompanied, however, by pyroxene, which is often quite as abundant. The two minerals are found grouped together, and evidently once formed part of the same rock.



SECTION OF ASH FROM SUMMIT OF RHOBELL-Y-BIG, MERIONETHSHIRE, × 5.

a, Augite, pale yellowish, with cracks and ovoid areas filled with green decomposition-products. A large cross-section is conspicuous above.

h, Hornblende, rich brown. The large lower one includes small granular pyroxene, but also has several almost colourless areas, across which the cleavage runs, and which may result from the substitution of secondary amphibole for some included mineral.

c, Hollows filled with chlorite, the right-hand one containing small secondary amphibole, and the left-hand one a border of yellow epidote.

Sometimes brown hornblende has developed paramorphically and sporadically within a large pale pyroxene; but much of the hornblende looks original and distinct. These crystals remind one so strongly of the Peridotites of Schriesheim or Loch Scye that one expects to find included olivine; but only a few green ovoid pseudomorphs in one specimen give direct countenance to this idea. The crystals are much torn and shattered; the cracks of the pyroxene have been filled up by chlorite, or by a very finely divided granular material; the hornblende has, however, been restored by a pale amphibole in optical continuity.[1] The hornblende crystals have also in places been extended by secondary amphibole, in flame-like protrusions, into the surrounding ash, and a number of actinolitic needles run through the altered groundmass.

In some of the hornblende crystals there are suspicious ovoid areas of a very pale green tint, across which the mineral is optically continuous. These may represent places from which olivine has been entirely removed, the gap being steadily filled in by the familiar pale secondary amphibole. A comparison of this structure with that of the olivine-bearing rocks of Menheniot, Schriesheim, etc., makes the suggestion seem at any rate not extravagant.

V. The Grits.

The detailed examination of the grit-bands proves their aqueous origin as clearly as is done by the larger pebbles in the field. It is rather difficult to know where all the quartz-grains came from—certainly not from any disintegration of the volcanic rocks of Rhobell. A few pebbles of compressed quartzite seem to point to the Harlech Grits as a source of origin, or even to the pre-Cambrian rocks from which those masses were derived.[2] The pebbles of lava are probably local, resembling the trachytic andesite series; and the abundant isolated plagioclases are additional evidence that the more felspathic eruptions occurred at the close of the volcanic action.

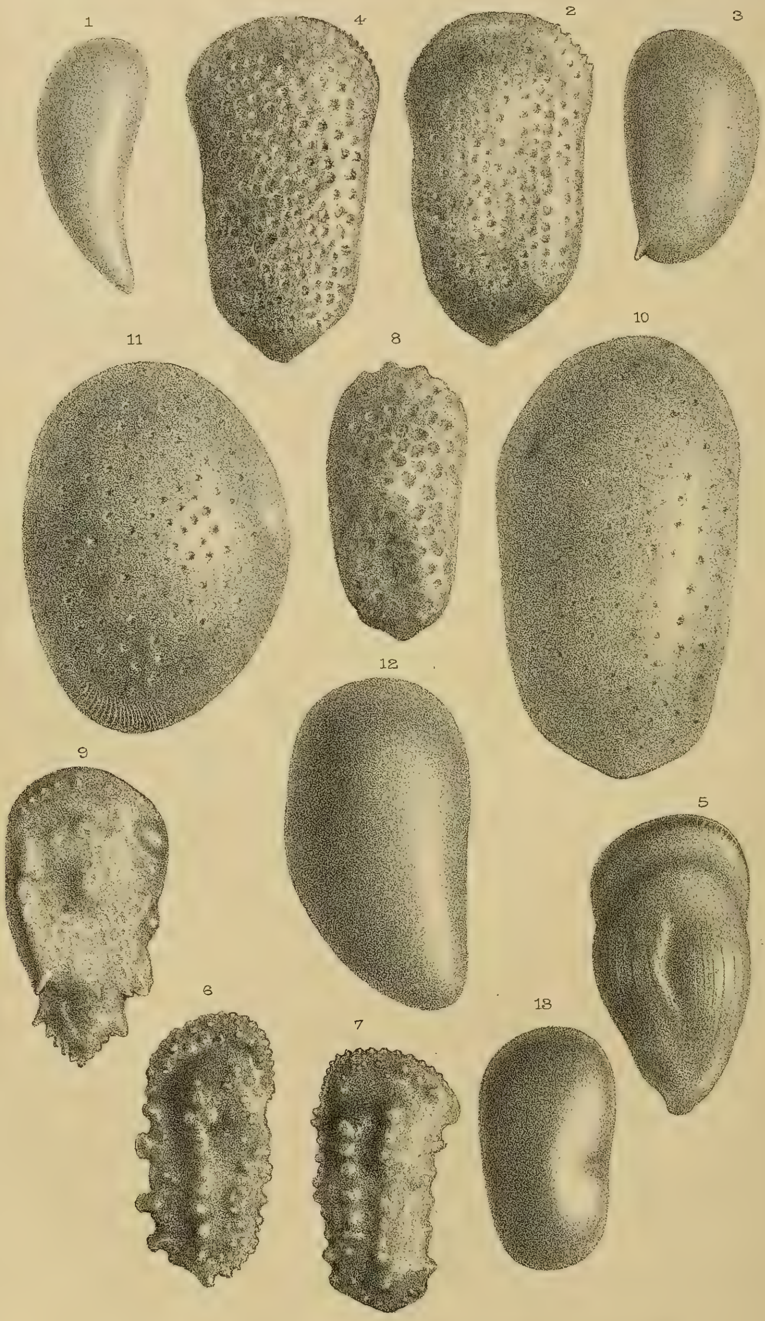
The most interesting constituents of the grit-beds are the ovoid black and grey bodies that show a concentric structure on weathering. Mr. Holland and myself[3] referred this structure to contraction; but microscopic sections show that it is in reality fundamental. These bodies, have, in fact, a rippled concentric mode of growth, and their layers appear transparent brown, colourless, or faintly green. Some of them include angular grains of quartz-sand, which show that they have arisen somehow in a sedimentary rock. On boiling the dark mass in hydrochloric acid, the greater part dissolves with effervescence, colouring the acid intensely yellow. A fine residue of quartz-sand, mica, and minute argillaceous particles, alone remains. These curious bodies may be referred, then, to the beds of pisolitic iron ore which were forming on the spot at the opening of the Arenig epoch; and they are, in fact, isolated concretions, often of large size, rolled out from those deposits. The best examples of them

---

[1] *Cf.* Marshall Hall, Geol. Mag. 1889, p. 480.

[2] *Cf.* Jennings and Williams, "On Manod and the Moelwyns," Quart. Journ. Geol. Soc. vol. xlvii. p. 373.

[3] *Loc. cit.* p. 449.



C.D.S. & F.C. del.
Woodward lith.
West, Newman imp.

New Ostracoda from the Gault.

that I possess are pale grey in colour, and occurred in a loose block of grit low down in the wood near Gell Fachreth. The faulting here, which brings down the Arenig ashes, may also have lowered the grit of Moel Cors-y-garnedd.

A series of sections from typical pisolitic and oolitic ironstones of N. Wales has facilitated this comparison; but the bodies in the grits of Rhobell evidently consist largely of ferrous carbonate, and have not undergone the reduction to magnetite from which most of the oolitic ironstone beds have suffered. This is the only evidence I possess of the occurrence of a ferrous carbonate stage in these deposits, though it has previously been hinted at[1] during a discussion of their mode of origin.

After assigning these concentric bodies to the layers of Arenig ironstone, it is strong support to find that Messrs. Jennings and Williams[2] have observed pebbles derived from the oolitic ironstone in a grit of the Arenig series in the Moelwyn area.

II.—ON THE OSTRACODA OF THE GAULT AT FOLKESTONE.

By FREDERICK CHAPMAN, F.R.M.S.,
and C. DAVIES SHERBORN, F.G.S.

(PLATE XIV.)

SINCE the year 1885 the various zones of the Gault at Folkestone have been systematically examined by one of us for the purpose of recording the Foraminiferal fauna of that deposit; the report upon which is now being published in the Journal of the Royal Microscopical Society.

At the same time the Ostracodal valves were isolated from the washings with the view of a similar report being made upon them; and it is thought that the publication of the results will be of some interest, in showing the distribution and relative abundance of these minute animals through the various deposits laid down in the Gault sea of that locality.

The extreme profusion of certain forms in particular beds is remarkable, and this segregation of species is often referable to the lithological differences met with in the various strata. (The nature of the deposits in the various zones and horizons is described in detail in the publication before mentioned.)[3] The slight connecting links of the Gault with the Jurassic Ostracoda on the one hand, and with those of Tertiary age on the other, have an additional palæontological interest.

But few new forms were met with, and this is strong testimony to the lifelong care bestowed upon the Cretaceous Ostracoda as a whole by Professor T. Rupert Jones. The results of his labours are embodied in a supplementary monograph of the Cretaceous Entomostraca of England and Ireland (Pal. Soc. 1890), of which we have

---

[1] Cole and Jennings, "Northern Slopes of Cader Idris," Quart. Journ. Geol. Soc. vol. xlv. p. 427.

[2] *Loc. cit.* p. 374.

[3] F. Chapman, The Foraminifera of the Gault of Folkestone, part i., Journ. Roy. Micro. Soc. 1891, pp. 566–572.

ZONAL DISTRIBUTION OF THE OSTRACODA IN THE GAULT AT FOLKESTONE.

	Zone i.		Zone ii.			Zone iii.	Zone iv.	Zone v.	Zone vi.	Zone vii.	Zone viii.	Zone ix.	Zone x.	Zone xi.										Mr. F. G. Price's Collection.	Godstone (Chapman & Sherborn).	C. Moore. Meux's well.
	Greensand Seam.	5 ft. from base.	Band of Crushed Ammonites	11 ft. from base.	13 feet from base.									55 ft. from the top.	50 ft.	45 ft.	40 ft.	35 ft.	30 ft.	25 ft.	20 ft.	12 ft.	6 ft.			
CYPRIDIDÆ.																										
Paracypris gracilis, Bosq.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*
,, *siliqua*, J. & H. ...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	3	2	1	2	1	12	...	2				
Pontocypris trigonalis, J. & H. ...	...	...	...	...	...	...	...	...	...	...	...	...	1	5	...	1	2	...	...	...	1					
,, *triquetra*, Jones	...	...	...	...	...	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...	...	1	2			
,, *Bosquetiana*, J & H.	1	...	...	3	1	...	...	2	3	...	2	1	2	1	3											
,, *attenuata*, Reuss. ...	...	...	...	...	...	...	...	...	...	...	...	3	2	...	2											
Bairdia subdeltoidea, Mün.... ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	18	1	9	...	*	
,, *Harrisiana*, Jones ...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	1	2	10	...	2	...	...	1	1			
Macrocypris Muensteriana, J. & H.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*
Bythocypris Reussiana, J. & H. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*		
,, *silicula*, Jones	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1				
,, ,, var. *minor*, J & H.	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	1	1						
CYTHERIDÆ.																										
Cythere Harrisiana, Jones	...	10	...	3	...	25	5	30	9	50	10	110	16	14	6	60	11	1	...	2	...	...	...	*	*	
,, ,, var. *setosa*, J. & H.	...	...	...	...	...	1	...	2	...	...	...	...	8	2	2	2	1	...	...	...	...	...	...	...	*	
,, ,, var. *reticosa*, J. & H. ...	...	...	...	...	...	6	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	
,, *lineatopunctata*, C. & S.	..	...	...	...	...	...	1																			
,, *gaultina*, Jones	...	...	...	...	...	...	...	...	...	...	...	1	6	...	...	...	...	...	...	...	...	3	3	*	*	
,, *Koninckiana*, Bosq. ..	...	6	1	...	...	...	1	4	...	...	...	...	...	...	4	...	1	1								
,, *spinifera*, C. & S.	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	2	1	1	1	1						
Cythereis triplicata, Röm.	...	25	1	1	2	2	1	6	...	6	1	...	5	1	1	3	1	10	10	12	4	16	14	*	*	
,, ,, var. *lineata*, C. & S.	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1				
,, *auriculata*, Corn.	1	6	...	4	1	13	3	14	3	11	20	11	16	13	8	6	1	2	1	1	16	2	1	...	*	
,, *quadrilatera*, Röm. ...	...	8	...	...	...	2	...	3	1	1	1	10	220	50	500	12	3	...	...	...	...	...	5	*	*	*
,, *ornatissima*, Reuss. ...	...	...	11	...	...	10	60	...	...	...	1	...	100	...	...	...	...	...	...	1	17	5	2	*	*	*

C. ornatissima, var. *rudispinata*, C. & S.	...	2	...	3	...	...	...	1	...	...	...	...	...	2												
,, ,, var. *paupera*, J. & H.	...	...	...	...	...	...	...	...	...	1																
,, ,, var. *nuda*, J. & H.	...	...	...	1	...	...	...	...	...	...	...	...	...	...	5	100	50	10	10	20	...	...	...	*		
,, ,, var. *reticulata*, J. & H.	...	5	...	2	...	3	6	8	1	...	3	3	30	4	8	5	3	3	4	12	14	3	7	...	*	
,, ,, var. *stricta*, J. & H.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3							
,, *excavata*, C. & S.	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	3	1			
,, *Wrightii*, J. & H., var. *aculeata*, C. & S. ...	...	1	...	...	...	2																				
,, *Lonsdaleana*, Jones ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100											
,, *vallata*, Jones	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1					
Cytheridea perforata, Röm. ...	2	40	60	4	9	16	100	2	13	7	1	3	18	1	9	4	10	11	23	60	2	13	3	*	*	*
,, ,, var. *insignis*, Jones	...	1	...	2	...	1	2	2	3	...	...	2	1	3	1											
,, *rotundata*, C. & S. ...	...	1																								
Pseudocythere ? simplex, J. & H.	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1										
Cytherura appendiculata, Jones ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*		
Cytheropteron concentricum, Reuss.	...	60	2	4	...	40	100	11	9	7	1	11	550	4	4	15	13	11	1	...	5	8	10	*	...	*
,, *alatum*, Bosq., var. *cornuta*, Bosq.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1					
,, *umbonatum*, Will.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1			
,, ,, var. *longispinata*, J. & H.	...	...	...	...	...	3	1	1																		
,, *Sherborni*, J. & H.[1] ...																										
,, *Folkestoniense*, C. & S. ...	...	1																								
CYTHERELLIDÆ.																										
Cytherella ovata, Röm.	...	4	1	2	4	9	3	8	18	7	2	11	550	3	110	60	4	10	50	50	4	5	63	*	*	*
,, *Muensteri*, Röm.	...	4	1	3	4	16	25	25	14	1	7	2	10	2	5	1	1	2	...	5	1	8	3	*	*	*
,, *subreniformis*, J. & H. ...	...	...	...	...	...	...	...	...	1																	
,, *Williamsoniana*, Jones ...	...	...	...	...	...	...	...	4	...	...	1	...	20	...	50	60	50	...	12	1	2	1	...	*	*	*
,, ,, var. *stricta*, J. & H.	...	...	...	...	...	...	...	1	...	...	1	3	50	5	2	3	1	1	...	...	...	...	1	...	*	
,, ,, var. *granulosa*, Jones	...	...	...	...	...	...	...	2	...	...	...	...	...	...	1	50	...	...	10							
,, ,, var. *Chapmani*, J. & H.	...	...	...	...	...	...	1	12	...	1	1	...	...	...	...	2	...	...	...	...	...	...	...	...	*	
,, *Beyrichi*, Reuss.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*
POLYCOPIDÆ.																										
Polycope, sp....	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...		...	...	...	...	...	*	...	*

---

[1] Recorded by Jones in error on p. 53, Mon. Cret. Entom. 1890.

made full use, while our special thanks are due to him for examining our material and verifying our determinations.

In the appended Distribution Table the numbers in the general columns refer to the approximate number of specimens found in the whole of the residual material after washing from 4 to 6 cubic inches of the rock.

The forms which appear to be new we now proceed to describe; and give (on pp. 346 and 347) a table showing at a glance the zonal distribution of the forms found in the Gault, and additional forms not found by us, but recorded elsewhere.

CYTHERE ? SPINIFERA, sp. nov. Pl. XIV. Fig. 3.

A smooth carapace, strongly arched on the dorsal, straight on the ventral side; with a projecting spine on the ventral margin at the hinder end. Hinge-line a simple flange.

Distribution.—Eight valves, from Zone x. and Zone xi., at 50 feet, 45 feet, 40 feet, 35 feet, 30 feet, and 25 feet from the top of the Gault at Folkestone.

CYTHERE LINEATOPUNCTATA, sp. nov. Pl. XIV. Fig. 4.

A strong carapace, much swollen at the ventral margin and overhanging; with coarse square punctations arranged in somewhat parallel lines. A central ridge, not very strongly developed, runs down the length of the shell.

Distribution.—One valve only, from Zone iv. of the Folkestone Gault.

CYTHEREIS TRIPLICATA, Röm. var. *lineata,* var. nov. Pl. XIV. Fig. 5.

These specimens possess the general form of *C. triplicata,* but have each of the lobes or ridges delicately ornamented with three or four longitudinal raised striæ.

Distribution—Two specimens, one with united valves from Zone i. 5 feet from the base, and the other from Zone xi., 12 feet from the top of the Folkestone Gault.

CYTHEREIS RUDISPINATA, sp. nov. Pl. XIV. Figs. 6, 7.

Closely allied to the many forms of Cythereis from the Cretaceous formation, and differing therefrom by having the three parallel ridges of curious and characteristic spines, which are spreading and flat at the apex, and in some specimens assuming large and pronounced mushroom-shaped prominences.

Distribution.—Eight valves from Zones i. (5 feet from base); ii. (11 feet from base); v., and xi. (55 feet from the top) of the Folkestone Gault.

CYTHEREIS EXCAVATA, sp. nov. Pl. XIV. Fig. 8.

Subquadrate, with an irregular front, just below which is a fenestrated much-raised ridge. The whole surface coarsely reticulate; rising up towards the hinder part of the carapace, standing away from the true margins, and terminating about seven-eighths from the front in a sharply defined edge.

Distribution.—One valve only, from Zone ix. of the Gault of Folkestone.

CYTHEREIS WRIGHTII, J. and H., var. *aculeata*, var. nov. Pl. XIV. Fig. 9.

The general characters of this form are similar to the type species; but the rounded processes seen in *C. Wrightii* are produced in this form into spikes and prickles. The front edge of the shell is very thin; the hinder end is produced into a long spike, and the margin in that region is strongly aculeate.

Distribution.—One valve from Zone i., 5 feet from the base; and two from Zone iii., of the Gault of Folkestone.

CYTHERIDEA ROTUNDATA, sp. nov. Pl. XIV. Fig. 11.

Valve of a subspherical form, with very coarse punctations showing as pimples on the inner surface. Hinge-line, a bar with a pitted socket at each end.

Distribution.—One valve only from Zone i., 5 feet above the base of the Gault at Folkestone.

CYTHEROPTERON FOLKESTONIENSE, sp. nov. Pl. XIV. Fig. 13.

Valve of an oblong shape and with the mid-dorsal sulcus well marked. The central area of the valve tolerably flat, and the slope to the ventral and dorsal margins steep. There is also a dorsal flange. The posterior portion of the carapace slightly higher than the anterior. Surface polished.

Distribution.—One valve only, from Zone i., 5 feet from the base of the Folkestone Gault.

EXPLANATION OF PLATE XIV.

FIG. 1.—*Pontocypris attenuata*, Reuss, right valve, × 50.
,, 2.—*Cythere Koninckiana*, Bosquet, left valve, × 50.
,, 3.— ,, ? *spinifera*, sp. nov., right valve, × 50.
,, 4.— ,, *lineatopunctata*, sp. nov., right valve, × 50.
,, 5.—*Cythereis triplicata*, Röm., var. *lineata*, var. nov., left valve, × 50.
,, 6.— ,, *rudispinata*, sp. nov., right valve, × 50.
,, 7.— ,, *rudispinata*, sp. nov., left valve, × 50.
,, 8.— ,, *excavata*, sp. nov., left valve, × 50.
,, 9.— ,, *Wrightii*, J. and H., var. *aculeata*, var. nov., left valve, × 50.
,, 10.—*Cytheridea perforata*, Röm., var. *insignis* (Jones), right valve, × 50.
,, 11.— ,, *rotundata*, sp. nov., left valve, × 50.
,, 12.—*Pseudocythere* ? *simplex*, J. and H., right valve, × 50.
,, 13.—*Cytheropteron Folkestoniense*, sp. nov., left valve, × 50.

III.—GLACIER OBSERVATION, MORE ESPECIALLY COLONIAL.

By Captain MARSHALL HALL, F.G.S., F.C.S.;
Member of the Alpine Club.

FOR many years the writer has wished for the means to bring about some uniform system of glacier observation, and more especially the collection of data respecting ice-movements in British Colonies, and territories under British influence. When we think of our mountains in the Dominion of Canada and in New Zealand, and the vast ranges of the Himalayas (these last we shall before long hear about from Mr. Conway), it seems a great pity that such promising fields should not be adequately worked. In an article in the Alpine Journal, for February, 1891, the writer sketched a plan of operation; and in the same Journal, for February, 1893, asked for a committee to communicate with such Colonial Governments as could take part.

Recently the Alpine Club has formed such sub-committee, and is about to appeal to the authorities. A Memorandum drawn up by the President, Mr. Douglas W. Freshfield, and which we subjoin, will be sent with each letter, in the hope that officers, surveyors, and explorers will be induced to give us their valuable aid.

The Memorandum in question only deals with the more pressing requirements as to ice-movements, etc., as it was not wished, in beating up recruits, to alarm such by too formidable an amount of work.

With regard to the suggestion in its last paragraph it will be as well to caution surveyors that, if a row of stakes is made use of, they should be of good size and planted deeply; surface ablation is rapid in hot weather, and Herr Escher von der Linth, having, on July 8, 1841, inserted stakes in holes 3 feet deep on the Aletsch Glacier, found, on August 16 (39 days later), all the stakes fallen, and no trace of the holes. Where available, rocks on the glacier surface, even though not likely to be in a straight line, are the best for surveying purposes. Even they have a bad habit of tumbling into crevasses! Mr. Brodrick, of the New Zealand Alpine Club, is early in the field, having determined the position of a considerable number of carried rocks near the lower end of the Mueller Glacier, and written an able account of ice-motion in the southern New Zealand Alps.

Readers of the Geological Magazine are little likely to take alarm if we mention a few additional points upon which facts would be of value, amongst others, some more especially in relation to the recently revived discussion of the part borne by glacier erosion in the formation of lakes. During sundry seasons the writer spent much time, without success, in attempts to find lakes indubitably produced by glacier action. Nevertheless, other men familiar with the ice-world may be more fortunate, and it is only just to distinguished supporters of the Ramsay theory that we should use our best endeavours to provide them with evidence.

We never remember to have seen terminal moraines of importance which are not, or have not been, cut through by the issuing torrent. In the case of the Mattmark See, in the Saas district, the lake was dammed back by the *lateral* moraine of the Alalin glacier, which, within the writer's memory, traversed the valley nearly at a right angle; but the glacier has retreated, and ten years ago the valley was so silted up that the lake was little more than a shallow pond.

The evidence as to the pace of the same glacier at different heights is none too copious, whilst the motion of the névé and of the snow masses which feed the ice is very little known. We look upon this last as almost new ground to break.

Professor F. A. Forel has recently caused lead plates, engraved with date, etc., to be buried near the summit of Mont Blanc.

The comparative amount of rocks and of detritus resting upon glaciers, and of that which has found its way beneath, and the amount removed by torrents from beneath ice, are difficult points which we recommend to good calculators more especially. Dr. A. R. Wallace especially draws the writer's attention to this.

How far are terminal made out of ground moraines?

The more adventurous will possibly not object to some unavoidable risk in explorations under the ice! Professor F. A. Forel has made many such trips. This leads us to expostulate with those who tell us that ancient glaciers were so enormous that for want of weight and pressure we cannot expect to find instances of lake-making in the puny glaciers of our day. The writer can scarcely imagine, having regard to the historical advance and retreat of ice, that such action can never be seen, similar in kind though not in degree. In fact this appears so palpable that in entire absence of existing work things would go hard with theories of former exploits.

We could multiply points of investigation almost *ad infinitum.* Here is plenty to do for many shrewd travellers. Nothing but personal experience in the higher mountains, where alone we can meet with ice masses, will avail to advance our stock of knowledge, and the writer can say that, although he has been a scrambler since the year 1848, he never remembers spending even a few days in the upper world without observing some phenomenon not previously impressed upon him, even if seen by him before.

Perhaps, after lapse of time, the comparative history of glacier movement in different latitudes and hemispheres may throw some light upon the question of periodicity, secular and other. Suggestions and reports, whether of much or little work, will be thankfully received either by the Hon. Secretary of the Alpine Club, 8, St. Martin's Place, Trafalgar Square, W.C., or by the writer, addressed to him, Easterton Lodge, Parkstone, Dorset.

Perhaps, as the next Congress of Geologists is to meet in Switzerland next year, some arrangements may then and there be come to, by which a chain of connection may for the future exist between different countries. Prince Roland Bonaparte undertakes the history of French Glaciers, except those of Mont Blanc, which Prof. F. A. Forel still takes in hand, as bound up with those of Canton Valais. How much we owe to his untiring enthusiasm!

Since writing the above, Professor Forel's capital monograph "Le Leman" has reached us.

Incidentally to the origin of the lake he gives much and valuable information as to the habits of glaciers.

This, only the first of three volumes, requires a notice of good length, to which we fain hope the Editor will turn his attention in due time.

"MEMORANDUM.

"The recent movements of glaciers may be noted by the following signs:—

"When the ice is advancing the glaciers generally have a more convex outline, the icefalls are more broken into towers and spires, and piles of fresh rubbish are found shot over the grass of the lower moraines. Moraines which have been comparatively recently deposited by advancing ice are disturbed, show cracks, and are obviously being pushed forward or aside by the glacier.

"When the ice is in retreat, the marks of its further recent extension are seen fringing the glacier both at the ends and sides in their lower portions, the glacier fails to fill its former bed, and bare stony tracts, often interspersed with pools or lakelets, lie between the end of the glacier and the mounds of recent terminal moraines.

"Where a glacier has retreated to any considerable extent, careful observations of the form of its bed are of value. What is the nature of the rock surfaces exposed—convex or concave; are they rubbed smooth on their leesides; how far have the contours of the cliffs or slopes, or the sides of any gorge, been modified where they have been subjected to ice-friction? Is there any evidence that the ice has flowed over large boulders, or loose soils, such as gravel, without disturbing them? How has it affected rocks of different hardness, for instance, veins of quartz in a less hard rock? Generally, do the appearances indicate that the glacier has excavated, or only abraded and polished its bed; that it has scooped out new rock-basins, or only cleaned out, scratched, and preserved from filling up by alluvial deposits or earthslips, existing basins? What is the general character of the valley bottom and slopes above and below the most conspicuous ancient moraines?

"The depth of mountain lakes and the position of the point of greatest depth should be ascertained wherever possible. The marginal rock structure of lake basins, particularly near their outlet, is of much importance with a view to ascertaining whether they are true rock basins, or whether they are reservoirs formed by ancient moraines, earthslips, or alluvial deposits.

"The traveller or surveyor should, if possible, paint a mark and date on any conspicuous rock *in situ* parallel with the termination of the glacier at the time of his visit, marking the distance in yards of the ice from it. The next visitor will then be able to measure the movement that has taken place since his predecessor's visit. Leaving out of question elaborate trigonometrical methods, such, for instance, as have been carried out on the Rhone Glacier in Switzerland, the following plan gives very valuable results, and demands no other instruments than a small jar of paint, a brush, a measuring tape, and a pocket compass. To ascertain the recent retreat of a glacier, measure the distance from the end of the ice in front of the longitudinal axis of the glacier to the most advanced terminal moraine, where vegetation first shows itself. The bare ground recently left by glaciers is easily recognisable. The diminution of volume is best measured by ascertaining the height of bare soil left on the sides of the lateral moraines in the portion of the glacier within the zone of vegetation. All photographic representations of the glacier end, and of the ground which has been freed from the glacier ice, are of great value. Those will be of most service that show the position of the glacier-snout with relation to some conspicuous rock or other feature in the local scenery. Each photograph should be dated, and the bearings and distance of the camera with reference to any such feature accurately noted.

"It is very important to investigate the state of various glaciers as regards advance or retreat. Neighbouring glaciers often furnish very different results in this respect, owing to the fact that steep glaciers anticipate in their oscillations those the beds of which are less inclined. To ascertain the oscillations of glaciers, it is necessary to fix the actual position of the ice-snout at the end of the glacier with the greatest accuracy. Two methods can be employed for this purpose, either of which may be selected according to circumstances.

"Paint some signs on large boulders, not too far from the end of the glacier, and measure their distance from it by a tape (Richter's system), or build a low wall of stones of a few yards in length, and, say 15 to 20 inches in height, some distance from the ice-end, and measure this distance (Gosset's system). It is to be recommended that the stones of these walls should also be painted. If the traveller himself returns after some interval—even after only two or three weeks—he will be able to judge of the movement of the glacier, and he will have laid down a basis for future observations by future travellers.

"One of the results most to be desired is an exact knowledge of the dates:

I. Of the maximum extension of the ice.
II. Of the commencement of retreat.
III. Of the minimum.
IV. Of the commencement of fresh increase.

"In dealing with a mountain group, therefore, the traveller should note (where he can get the information as to the past) the date of the commencement of the actual movement of *each glacier*, and in all cases whether the ice is in advance, or retreat, or stationary. Of course the rate of forward movement, or velocity of the ice, and the oscillations in the extension of the ice must be kept carefully distinct.

"Should time and circumstances permit, a series of observations of the velocity of the ice is of value. These may be made after Tyndall's method, by planting a line of sticks across the glacier, or by painting marks on boulders, the position of which relatively to ascertained points on the mountain-side has been accurately fixed. The size of the glacier, that is, the area of its basin and its length, as well as the slope of its bed above, as well as at the point measured, should be noted. The rate of movement of the ice appears to be connected both with the volume of the glacier and the inclination of its bed."

IV.—THE TRUE HORIZON OF THE MAMMOTH, ETC.: BEING A REPLY TO MR. MARK STIRRUP, F.G.S.

By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S.

THE very great importance of the issues involved if we are to make any definite progress in the study of the later deposits must be my excuse for this reply to Mr. Stirrup's letter. He says that the only available material for discussing the results of the expedition of Toll and Bunge to the Siberian islands is an abstract published by Schmidt some months ago. In this he is surely mistaken. A considerable volume giving detailed information about the expedition has been published for some years in the "Beiträge zur Kenntniss d. Russ Reiches," while more than three years ago an elaborate memoir on the geological and palæontological results of the expedition was read before the St. Petersburg Academy, which has since been translated into German and published in a large quarto. The author of this memoir, Tscherski, is an authority of the first rank upon the geology of Eastern Siberia. Since 1873 he has devoted many years to a personal examination of that little known area, and is probably better qualified to give a sound opinion upon some critical questions regarding it than anybody living.

As to the former existence of a so-called Glacial Period in Siberia he is most emphatic. Krapotkin claimed to have found relics of a widespread glaciation in the mountains of Eastern Siberia, while Czekanovski professed to find similar traces in the Sayanian Mountains. Tscherski absolutely contests this, and declares that in the Mountains of Eastern Siberia there are only traces, and these very slight ones, of individual local glaciers. He says that the supposed scratched blocks from the bed of the River Yenissei near the foot of the Sayanian Mountains, and which are preserved in the Museum of the Imperial Academy of St. Petersburg and in the Museum at Minussinsk, are merely examples of weathering and were so accepted by the geologists who examined them at St. Petersburg. He says that with the exception of a small area west of the Baikal, there are not to be found on the meridian of that sea, nor in the high plateau behind it, including the so-called Apple Range, any indications of the former existence of glaciers. It will thus be seen that the position I argued for, and which I believe is accepted by such an extreme advocate of glacial views as Mr. James Geikie, that there are no traces of a so-called glacial age in Siberia, is fully sustained by the latest and best information on the subject, and that the observations of Von Cotta in the Altai Mountains, and of Nordenskiold along the Polar Sea, are fully borne out by the observations of Tscherski in Eastern Siberia.

This being so, it is not surprising that the latter writer should add that hitherto no traces of so-called inter-Glacial beds have occurred in Siberia nor, he says, in the greater part of European Russia.

I am still at a loss to know upon what evidence and what authority Mr. Stirrup classes the rolled gravels underlying the Mammoth beds in Siberia as glacial deposits. I know of no evidence to support such a contention.

Turning to another side of our discussion, namely, the true horizon of the Mammoth, I should like to quote a statement of Tscherski, in which he refers to the well-known famous skeleton of a Mammoth found at Troizkoya, near Moscow, and which he says lay distinctly in a marine *pre-Glacial bed.* He refers to the section given by Nikitin in vol. ii. of the Memoires du Comité Géologique. He also refers to the deposit of Pleistocene animals discovered in 1878 in the government of Smolensko by Professor Dokutschayef, and which he says lay in a similar deposit. Its discoverer attributed it, apparently on *a priori* grounds, to a post-Glacial age, but this view is contested and disposed of by Tscherski, who is supported by Nikitin (see the discussion in the Memoirs of the St. Petersburg Academy, vol. 40, p. 474). This shows how the case for the post-Glacial existence of the Mammoth is everywhere crumbling away. I must, in conclusion, refer shortly to Mr. Stirrup's quotations from Favre in regard to the age of the Mammoth in Savoy, etc. He seems to me to have entirely misapprehended the views of that geologist. There is not, so far as I know, any question among French geologists in regard to the meaning of the term "Alluvion Ancienne," which was first used, I believe, by Necker, in 1841, when he separated the so-called diluvial beds near Geneva into two horizons, the lower one of which he called Alluvion Ancienne, and the upper one "terrain diluvian cateclystique." Since his time the meaning of the term "Alluvion Ancienne" has remained fixed and always connotes a pre-Glacial and not a post-Glacial deposit, and Favre retained this connotation when in 1862 he altered Necker's "diluvium cataclystique" into "terrain glacière." Favre, like all other French geologists, treats this Alluvion Ancienne as pre-Glacial.

What there is a difficulty about is, not as to the horizon of the Alluvion Ancienne, but as to the age of the so-called "Alluvion de terraces," which Favre separated from the other two diluvial deposits, and which he no doubt says does overlie his "terrain glacière." Now the age of these terrace-gravels, like the age of the brick-earths of the Thames Valley, has been disputed. I believe there is no evidence of superposition, and the question has been decided on *a priori* grounds, which, I venture to think, are worthless in such a discussion. The contents and the character of these terraces seem to me distinctly to point to their being of the same age as the Alluvion Ancienne of the valleys, and to be, therefore, pre-Glacial, in the sense in which that word is generally used, and not Post-Glacial. Favre mentions three instances, and three only, as far as I know of the occurrence in these terrace-gravels of remains of Pleistocene mammals; in two instances remains of the Mammoth and in the other of the Reindeer. May I add that in regard to the most famous Pleistocene deposits of Savoy, namely, the lignites of Sonnaz, they distinctly underlie glacial deposits, while Favre himself says that no glacial deposit has been found below the lignites of Savoy, or that of the Bois de Batie. These lignites, so far as the most recent evidence goes, are on the same horizon as those at Durnthen, about which, as I showed, Heer changed his views. I cannot see, therefore, how in any single instance Mr. Stirrup can sustain his case, and, so far as I know (in the Old World at all events), there is no evidence whatever which is not tainted with doubt and difficulty to support the post-Glacial date of the Mammoth and his companions, while there is overwhelming evidence that their remains occur *under* the so-called Glacial beds.

V.—NOTE ON THE QUETTA EARTHQUAKE OF DECEMBER 20TH, 1892.

By CHARLES DAVISON, M.A.,

Mathematical Master at King Edward's High School, Birmingham.

ON the morning of December 20, 1892, a severe earthquake was felt in the neighbourhood of Quetta in British Balúchistán. Some of the remarkable effects of this shock have already been described in a paper in "Engineering" for May 19, by Mr. R. W. Egerton, the executive engineer in charge of the Shalabagh division of the North-Western Railway. The present note is founded partly on this paper, and partly on further details contained in letters written by Mr. Egerton to his father, Sir R. E. Egerton, K.C.I.E.[1] and to myself. It will thus be seen that everything that is of value in this paper is due to Mr. Egerton's careful observations; my own part has simply been to edit these notes and to select from them those particulars which appear to me of most interest to geologists.

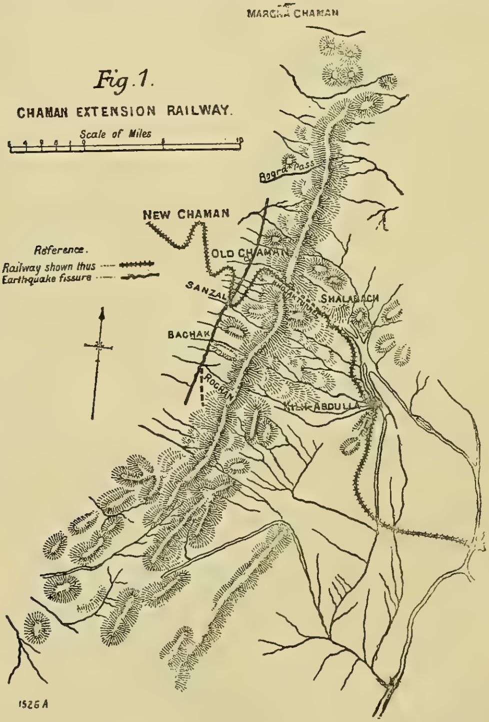


Fig. 1.

CHAMAN EXTENSION RAILWAY.

Soon after the close of the last Afghan war a new railway was begun, in order to connect the important positions of Quetta and

---

[1] My thanks are due to Dr. Lapworth for placing me in communication with Sir Robert Egerton, and to the latter gentleman for the many extracts which he has kindly sent me from his son's letters; also to the publisher of "Engineering" for his courtesy in allowing me to reproduce three of the five illustrations which accompanied Mr. Egerton's paper.

Kandahar with the railway-system of North-western India. Leaving the main line at Sukkur, on the Indus, the new line passes by Jacobabad, Sibi and Quetta; and, about forty or fifty miles beyond the latter place, it cuts through the Khojak Range in a tunnel nearly two-and-a-half miles long, emerging afterwards on the plain of Kandahar. Mr. Egerton's map of the district on either side of the Khojak tunnel is given in Fig. 1. As the country beyond is little frequented by Europeans, the limits of the disturbed area must probably remain unknown, but part or the whole of the epicentrum certainly lies within the district shown in this map.[1]

Mr. Egerton was stationed at Shalabagh, on the east side of the Khojak Range. The shock was felt there at 5.40 a.m. (probably local time), and was strong enough to damage buildings, rendering many of them unsafe, and throwing several down. "In the Khojak tunnel," according to the "Pioneer" newspaper, "the noise was deafening, and workmen engaged on the roofing were thrown from their perches to the ground." After this earthquake slight shocks were frequently felt, sometimes two or three a day during the first month, then almost daily until the end of February, after which the intervals between them became longer, so that during May only about two or three tremors were felt every week. None of these shocks approached the first in severity, though for some time they were strong enough to keep the engineers in continual fear for the safety of the tunnel.

The phenomena of chief interest occurred in the epicentral tract which lies immediately on the west side of the Khojak Range. Between Sanzal and Chaman stations, and about 2½ miles north of the former, both lines of metals, together with the sleepers, were twisted into a loop, as if they had been pieces of string (Figs. 2 and 3). Fig. 3 is copied from a photograph taken by Mr. L. Gordon, the traffic superintendent of the district. Both lines were contorted in the same manner, but the up-line was removed for repairs before the photograph could be taken.

The bending and crumpling of railway-lines is not an uncommon result of severe earthquakes. During the Charleston earthquake of August 31, 1886, the lines were in places bent or displaced for about twelve miles on either side of the epicentrum. In the region of maximum disturbance, the flexures were frequent and sometimes resembled those shown in Fig. 3. Here, the buckling always took place against some rigid obstacle, usually a long rigid trestle, and was accompanied by a corresponding extension of the line in the neighbourhood, by the opening of the joints and shearing of the fish-plate bolts.[2]

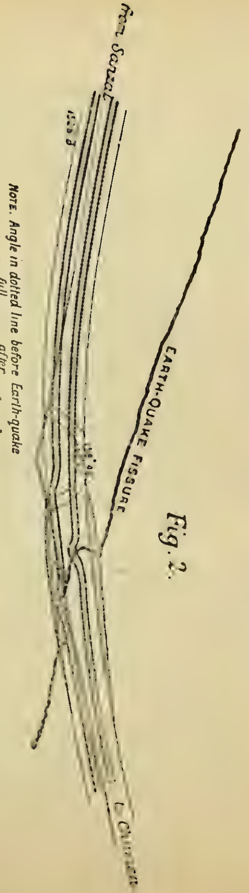
In the present case, however, all the neighbouring fish-joints were jammed up tight; and, when Mr. Egerton removed the crumpled lines, it was found that the new lines had to be cut 2 feet 3 inches

---

[1] Few atlases contain maps of the whole district. A rough sketch-map is given in Chambers's Encyclopædia, vol i., article on "Afghanistan."

[2] Captain C. E. Dutton, The Charleston Earthquake of August 31, 1886; United States Geol. Survey, Ninth Ann. Rep., pp. 283–295.

Fig. 2.



NOTE. Angle in dotted line before Earth-quake
" " full " after " "

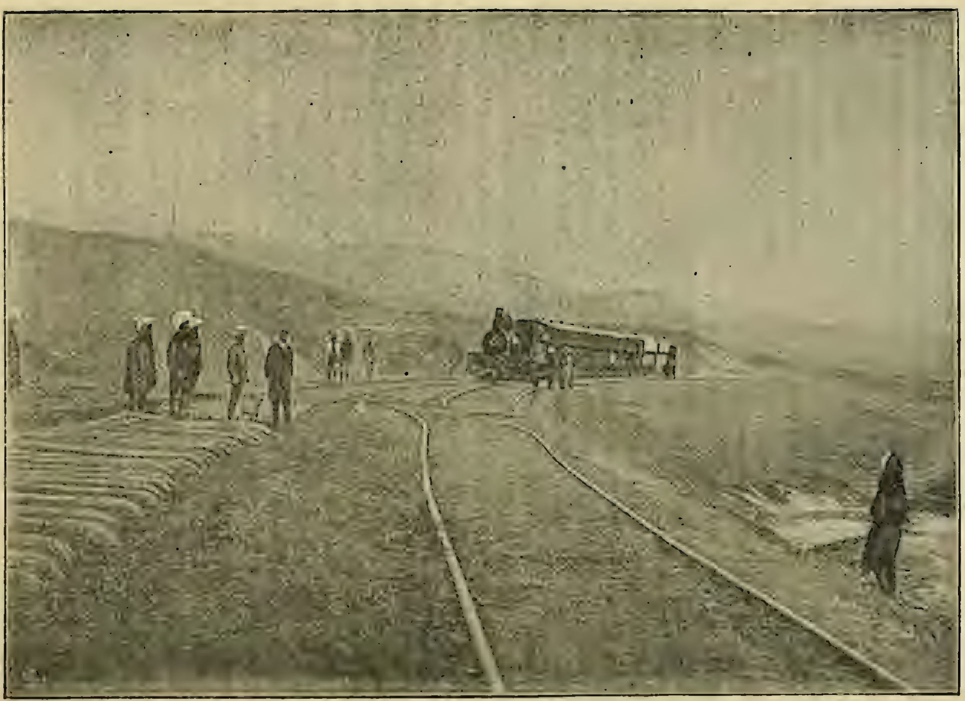


FIG. 3.—Reproduction of Photograph by Mr. L. Gordon, showing distortion of down-line of Rails by Earthquake, between Sanzal and Chaman. (See Mr. A. B. W.'s letter, p. 380.)

shorter than the old ones. There must, therefore, have been an actual and permanent displacement of the earth's crust in this district, not less, and possibly more, than the above amount. It need hardly be said that this is a most unusual occurrence, and one of which every additional illustration and proof is of the greatest value to geologists.

When the earthquake was over, a fresh crack was observed in the ground, crossing the lines at an acute angle exactly at the spot where the crumpling took place. The fissure runs nearly in a straight line, parallel to the Khojak Range (*i.e.* about N.NE. and S.SW.) and about three miles to the west of its central line (Figs. 1 and 2). It coincides almost exactly with a line of springs, and was clearly produced by a fresh slip along an old line of fault. Mr. Egerton has traced the fissure for several miles in both directions. "It was quite curious," he says, "to look at it from certain points which commanded a long view. The old fault-line was then so very obvious that I wonder now how it was never recognized as such before; R—— used to think it was an old road, he told me when I showed it to him." The length of the fault is unknown. Towards the north, it runs out of British territory. Towards the south, it passes just to the east of the low hills in the south-west corner of the map, and it is believed to cross the low neck which joins the Khwaja Amran Peak with the Khojak Range.

It is to be regretted that the actual amount and direction of the movement could not be determined, though Mr. Egerton examined the fissure at various points with this object in view. We may form some idea of its nature, however, from the facts which he has observed. A revision of the levels crossing the fissure shows a difference of ·16 of a foot, or nearly two inches, but it is not stated which side is now relatively the higher. From the crumpling of the lines and closing up of the fish-joints, it is clear that there was a horizontal movement parallel to the fissure; either the west side moved southwards or the east side northwards. Also, it will be seen from Fig. 2 that the curvature of the line near the fissure was slightly less after than before the earthquake. If the movement had been entirely parallel to the fault, the curvature would have been unaltered, or, if anything, slightly increased. There must, therefore, have been motion in a line at right angles to the fault, so that the rock-masses approached one another, implying that the fault is a reversed one. From Fig. 2, again, it would seem that the direction of the railway-line has been changed on the east or Sanzal side of the fissure, and not on the west or Chaman side; showing probably that the eastern rock-mass was moved against the western, as if the Khojak Range were being thrust bodily towards the plain of Kandahar.[1]

---

[1] It may be interesting to compare with this Prof. Milne's account of the changes wrought by the great Japanese earthquake of 1891. "The immediate cause of this great disturbance," he says, "was apparently the formation of a fault which, according to Dr. B. Koto, can be traced on the surface of the earth for a distance of between forty or fifty miles. In the Neo Valley, where it runs nearly N. and S., it

The evidence in favour of this latter point is of course not decisive. But as the natives declare that the ground always cracks along the old fault-line whenever there is a severe earthquake, it is probable that before long Mr. Egerton and his colleagues may be in a position to renew their very interesting observations, and thereby to extend our knowledge of the crust-movements that are now taking place.

NOTICES OF MEMOIRS.

Researches on the Structure, Organization, and Classification of the Fossil Reptilia. Part VIII. On Further Evidences of *Deuterosaurus* and *Rhopalodon* from the Permian Rocks of Russia. By Prof. H. G. Seeley, F.R.S. Royal Society, June 8, 1893.

THE author endeavours to separate the Labyrinthodont remains, distinguished by having teeth anchylosed to the jaw, from such as belong to animals having a Theriodont type of dentition. The genera founded upon cranial fragments which show the Theriodont type are *Deuterosaurus*, *Rhopalodon*, and *Dinosaurus*. The skull in *Deuterosaurus* is described from new materials, which make known the structure of the palate and other cranial structures. The palate is of Plesiosaurian type. The back of the skull is a vertical plate, and the brain cavity rises in a long vertical tubular mass to the parietal foramen. The quadrate bones descend below the foramen magnum in a way that is best compared with Plesiosaurs.

The articular end of the lower jaw is identified among bones figured by von Meyer.

The skull of *Rhopalodon* is nearly complete, and has a general resemblance to the skull of the South African Dicynodont *Ptychognathus*. The orbit is defended with a sclerotic circle of bones. Whereas in *Deuterosaurus* there is only one molar tooth, in *Rhopalodon* there are apparently eight molar teeth, which have the posterior edge finely serrated.

The vertebræ are known from isolated and connected specimens which indicate a larger number than usual of rib-bearing presacral vertebræ, which appear to be not fewer than nineteen, and may have numbered twenty-six. The sacral vertebræ are deeply cupped, and the sacral ribs are developed as in *Nothosaurus* and *Pareiasaurus*. The sacral ribs form part of the articular face of the first sacral vertebra. The pelvis is imperfectly known; the ilium is not so

---

looks like one side of a railway embankment about 20 or 30 feet in height. . . . . . Not only is there evidence of subsidence along this line, but there are many evidences of horizontal displacement. Lines of roads have been broken, and one part of them thrown to the right or left of their original direction; whilst fields which were rectangular have been cut in two, and one-half relative to the other half been shifted as much as 18 feet up or down the valley. One result of this is that landowners find there has been a partial alteration in the position of their neighbours. A more serious change has been the permanent compression of ground, plots which were 48 feet in length now measuring only 30 feet in length. It appears as if the whole Neo Valley had become narrower. A similar effect is noticeable in the river-beds, where the piers of bridges are left closer together than they were at the time of their construction."—Brit. Asso. Rep. 1892, pp. 116, 117.

extended as in Dicynodonts, and conforms to the type of *Phocosaurus*, which is regarded as Theriodont. The pubis and ischium are united together on the Dicynodont plan, but are only moderately developed.

The scapular arch is completely known, and is formed of scapula, coracoid, and pre-coracoid, as in *Dicynodon* and *Pareiasaurus*. The humerus and bones of the fore limb were relatively short, and only fragments have been preserved which appear to be referable to ulna and radius.

The hind limb is known from several examples of the femur, which resembles that of *Pareiasaurus* in the proximal end, but at the distal end is more like the type described as *Saurodesmus*.

The tibia is known from its proximal and distal ends; it has a general resemblance to that of *Pareiasaurus*, but is more slender. These types are regarded as constituting a distinct group, named Deuterosauria, which is in many respects intermediate between the Placodontia and Theriodontia, but in skull structure appears also to approach Nothosaurs and Plesiosaurs.

REVIEWS.

I.—TEXT-BOOK OF COMPARATIVE GEOLOGY. By E. KAYSER, Ph.D. Professor of Geology in the University of Marburg. Translated and Edited by PHILIP LAKE, M.A., F.G.S., late Harkness Scholar in the University of Cambridge. 8vo. pp. 426, with 596 Illustrations, 73 Plates and 70 Figures in the Text. (London: Swan, Sonnenschein & Co., 1893.)

IN undertaking the translation of Dr. Kayser's "Lehrbuch der geologischen Formationskunde" Mr. Philip Lake has done more than preparing a mere translation. Dr. Kayser's work was intended primarily for use in Germany, it has therefore been found desirable, in the present edition, to very considerably enlarge those portions of the work which deal with descriptions of extra-German countries. Mr. Lake has taken the advice of several of his geological colleagues, whose assistance he duly acknowledges, and amongst other modifications he has introduced the divisions Cambrian, Ordovician, and Silurian, instead of the older subdivisions into Cambrian and Silurian only.

In the introduction the author gives a history of the names which have been adopted in this country and in Germany for the great series of stratified deposits, and the various subdivisions now generally recognised by geologists both at home and abroad.

Division I treats of the general characters and composition of the Archæan rocks, illustrated by ten sections. The total thickness of the Archæan in North America has been estimated at 50,000 feet, and in Bohemia at 100,000.

In II the Palæozoic or primary group is considered, comprising the Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian, the six systems forming together a succession of beds fully 100,000 feet thick.

Under "Cambro-Silurian Rocks" the author gives an epitome of what has taken place with regard to the subdivisions adopted by Sedgwick, Murchison, the Geological Survey, Lyell and finally Lapworth. The general consensus of opinion seems now to be in favor of the acceptance of Professor Lapworth's tripartite division :

SILURIAN	Downtonian	
	Salopian	
	Valentian	
ORDOVICIAN	Bala Series	
	Llandeilo	
	Arenig and Llanvirn	
	Tremadoc Slates	
CAMBRIAN	Lingula Flags :	*Olenus* Beds
	Menevian	*Paradoxides* Beds
	Harlech, &c.	
	Comley Sandstone:	*Olenellus* Beds
	Caerfai group	

Under each subdivision the English and Foreign equivalents will be found together, with upwards of a hundred figures of the characteristic fossils that mark the several stages.

Thirty-six pages are devoted to the Devonian System, principally based on foreign localities; but a summary is given of (1) the succession of beds in North and South Devon, consisting of a series of slaty, sandy, and calcareous beds, which in all points resemble that of the continent, and (2) a thick red sandstone series, distinguished by a rich and peculiar fish fauna, the Old Red Sandstone.

The author gives tables of the Devonian rocks as shown in the Rhine area; the Ardennes; in Thuringia and in the Alps; in France; Spain and Portugal; in Bohemia; the Urals in Russia; and in North America. The Palæontology is carefully dealt with and illustrated by upwards of seventy wood-cut figures of fossils.

Thirty-eight pages are devoted to the Carboniferous System and its palæontology, with sixty illustrations besides sections of strata.

The Permian is next described, special attention being given to its European development, it having been known longest in Central Germany, especially about Mansfeld, where, for centuries, important mines have been worked in the Permian Kupferschiefer, and where the old names, Rothliegende and Zechstein, had their origin.

Its distribution in Germany, France, Britain, Russia, the Alps, Sicily, Asia, America is given; it is also recorded from Spitzbergen and New Scotland, Australia, India, and Africa. Upwards of thirty figures of Permian fossils are introduced.

III. The Mesozoic or Secondary group commences with the Trias, to which forty-one pages are devoted. Stress is laid on the great difference between the "German" and "Alpine" facies of the Trias; in the former, with the exception of the calcareous Muschelkalk, the beds are mainly sandy or argillaceous rocks,—in England indeed these form almost the whole series. In the Alps, on the other hand, the sandy rocks are very much reduced in comparison with the massive pure limestones, dolomites, and marls.

In Germany only the Muschelkalk contains a fauna of any abundance, the Keuper and Bunter being very unfossiliferous. But the Muschelkalk even is poor when compared with deposits of the same age in the Alps. This is especially true of the deep-sea Cephalopoda, which in the German Trias are known by a few small species, but in the Alpine Trias by a whole series of rich faunas. The widespread Alpine Trias is the pelagic facies of the formation; the more restricted German Trias, on the other hand, is a shallow shore, bay, or inland sea formation. The fossils of this division are illustrated by about seventy woodcuts, and comparative tables of the German and Alpine Trias in various areas are given.

Forty-four pages are devoted to the Jurassic System and seventy figures to the illustration of its fossils.

Tables are also furnished of the Liassic and Oolite strata and their equivalents abroad.

Forty-six pages contain the Cretaceous system, illustrated by ninety figures, whilst seventy-three pages, and one hundred and twenty figures are devoted to the Tertiary Age.

Making due allowance for the difficulties of bringing out such a work, the author and translator may both be congratulated on the satisfactory appearance of the English Edition.

The figures are mostly needlessly large, which is a misfortune, causing them to take up too much space; the Mammoth and Irish Deer should be condemned as bad, and we should like to see more regard paid to the *relative proportions* of the figures of natural objects used in such works as the present.

Prof. Prestwich, in his admirable Manual of Geology (1888), has set an example in the matter of illustrations which other writers on palæontology might do well to follow.

For a small handy volume, we must commend Mr. Lake's translation of Dr. Kayser's Geology as worthy of a place in any library, forming a useful and trustworthy guide-book to the student. The facts are clearly and carefully given, there is a good index, and the price of the volume is conveniently small.

II.—THE GLACIAL NIGHTMARE AND THE FLOOD, A SECOND APPEAL TO COMMON-SENSE FROM THE EXTRAVAGANCE OF SOME RECENT GEOLOGY. By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S. Two vols. 8vo. pp. xxviii., xii., and 920. (London: Sampson Low, Marston, & Company, 1893.)

THE name of Howorth has long been familiar to the readers of the GEOLOGICAL MAGAZINE, as a constant contributor since 1880, on "The Mammoth in Siberia," "The Mammoth in Europe," "On the Loess," "Traces of a great Post-Glacial Flood," "The Mammoth and the Glacial Drift," etc. Many of the chapters of his first great book, "The Mammoth and the Flood," which some of his friends playfully called a "Monster Book," appeared in the monthly numbers of this MAGAZINE, as have also portions of this his newest publication.

"One of the chief objects," says Sir Henry Howorth, "of this book, is to show that the Glacial theory, as usually taught, is not sound; but that it ignores, and is at issue with, the laws which govern the movements of ice, while the geological phenomena to be explained refuse to be equated with it. This is partially acknowledged by the principal apostles of the ice-theory. They admit that ice as we know it in the laboratory, or ice as we know it in glaciers, acts quite differently to the ice they postulate, and produces different effects; but we are bidden to put aside our puny experiments which can be tested, and turn from the glaciers which can be explored and examined, to the vast potentiality of ice in shape of portentous ice-sheets beyond the reach of empirical tests, and which we are told acted quite differently to ordinary ice. That is to say, they appeal from sublunary experiments to *à priori* arguments drawn from a transcendental world. Assuredly this is a curious position for the champions of uniformity to occupy. In regard to it I will quote a fable already utilized by Hugh Miller. A wolf, says Plutarch, peeping into a hut where a company of shepherds were assembled, saw them regaling themselves with a joint of mutton. 'Ye gods!' he exclaimed, 'what a clamour they would have raised if they had caught *me* at such a banquet.'

"I hold that the Glacial Theory, as ordinarily taught, is based, not upon induction, but upon hypotheses, some of which are incapable of verification, while others can be shown to be false, and it has all the infirmity of the science of the Middle Ages. This is why I have called it a Glacial Nightmare. Holding it to be false, I hold further that no theory of modern times has had a more disastrously mischievous effect upon the progress of Natural Science. It is not merely in the domain of geology that its baneful influence will be felt. We cannot take up a text-book in which the profounder problems of biology are treated, problems like the distribution of animals and plants, the pedigree of life, the origin and beginnings of the human race, without being impressed with its influence as a factor." . . . .

"What then is shortly the burden of the following argument? I admit completely, that the position maintained by Charpentier in his work on Glaciers is unassailable, first, because it makes no appeal to any occult and hidden forces underlying the movements of ice, but proves the existence of greater glaciers formerly by comparing and equating the ruins they have left with the ruins made by existing glaciers. Secondly, because it is consistent with all the geological facts that we can summon to test it by. On the other hand, I not only disbelieve in, but I utterly deny, the possibility of ice having moved over hundreds of miles of level country, such as we see in Poland and Russia, and the prairies of North America, and distributed the drift as we find it there. I further deny its capacity to mount long slopes, or to traverse uneven ground except when under the impulse of gravity. I similarly deny to it the excavating and denuding power which has been attributed to it by those who claim it as the excavator of lakes and valleys, and I altogether question the legitimacy of arguments based upon a supposed physical capacity which cannot be tested by experiment, and which is entirely based upon hypothesis. This means that I utterly question the prime postulate of the glacial theory itself."

What then is the alternative which Sir Henry Howorth offers for our acceptance in lieu of the glacial theory which he contemns? "It is a widespread flood, which seems to be a necessary postulate, if we are to adequately grapple with the extinction of the Pleistocene fauna, and an equally necessary postulate if the geological facts are to be duly explained." . . . .

"The Pleistocene Flood, though far from being universal, was certainly one of the most widespread catastrophes which the world has seen. It forms a great dividing-line in the superficial deposits as was maintained long ago, and as such it is a very useful landmark which ought to appear in our nomenclature, and I do not know of any better terms than ante-diluvian and post-diluvian to mark the two great divisions of the post-Pliocene-beds.

"Ante-diluvian times, so far as we can see, were marked in the temperate latitudes of both hemispheres by accumulations of ice in the shape of large glaciers on the high lands (then probably much higher) of Western Europe, of North America, of Australia, New Zealand, and perhaps South Africa. Alongside of these glaciers, and in contact with them in all these latitudes, were wide champaign and wooded districts in which the Mammoth and the Woolly Rhinoceros were the most prominent animals in North Asia and Europe, the Mammoth and the Mastodon in North America, the Mastodon and the great Sloths in South America, the various species of gigantic Kangaroos and Wombats in Australia, the great wingless birds in New Zealand. They lived and thrived in the near neighbourhood of the ante-diluvian glaciers, just as the Apteryx now thrives in the luxuriant forests near the great glaciers in New Zealand, and just as the Tiger and the Rhododendron thrive close to the Himalayan glaciers.

"Meanwhile, in Northern Asia and Western Europe and in North and South America certainly, and probably also in Australia, antediluvial man lived alongside of and hunted the ante-diluvian animals, and if we are to clear up his pedigree we must find the true interpretation of these ante-diluvian beds.

"Presently came a tremendous catastrophe, the cause of which, as I have tried to show in the GEOLOGICAL MAGAZINE, was the rapid and perhaps sudden upheaval of some of the largest mountain-chains in the world, accompanied probably by great subsidences of land elsewhere. The breaking up of the earth's crust at this time, of which the evidence seems to be overwhelming, necessarily caused great waves of translation to traverse wide continental areas, as Scott Russell, Hopkins, Whewell, and Murchison argued they would, and these waves of translation as necessarily drowned the great beasts and their companions, including palæolithic man, and covered them with continuous mantles of loam, clay, gravel, and sand, as we find them drowned and covered. They also necessarily took up the great blocks which the glaciers had fashioned, and transported them to a certain distance and distributed them, and the drifts associated with them, as we find them distributed.

"This Induction, whose details are contained in the following pages, seems to me to be complete, not only because it adequately explains the facts, but because it is the only theory that does so, and I know nothing against it, but the almost pathetic devotion of a large school of thinkers to the Religion founded by Hutton, whose High Priest was Lyell, and which in essence is based on *à priori* arguments like those which dominated mediæval scholasticism and made it so barren."

Truly, time brings its revenges! The school of Cataclysmists and Convulsionists, which, 25 years ago, we believed had entirely died out, has found a most powerful advocate in Sir Henry Howorth. Even the most extreme of glacialists must feel a glow of satisfaction in the thought that their opponent advances cataclysmic views as piping hot as theirs are frigidly cold.

Humboldt's Jorullo, run up in a single night, is as a rushlight to the mighty Himalayas jerked up by Sir Henry Howorth in a week!

Nor can the glacialists pretend to any chance of competition with the author in monster Ice-sheets compared with a Flood so extensive as he presents for our immersion.

Assuming Sir Henry Howorth is right in his theory and all other geologists wrong, how comes it that the pigmy descendants of the giant sloths and the mighty *Glyptodon* should be found occupying the same area in South America as their huge forefathers, and that the extinct *Diprotodon* and *Nototherium* of Australia should be represented by corresponding but lesser living forms of Marsupials in that area to day? May not each and all the changes in the mammalian and avian faunas of the various great regions of the earth have been due to causes which have acted independently in each great area, and which may have been brought about by very distinct and separate agencies? Thus the great Marsupialia of Australia may have owed their extermination to a succession of dry seasons, which, as Sir Richard Owen pointed out, always affect the larger animals first, by producing scarcity of food and water. The great *Dinornithidæ* in New Zealand probably owed their extermination partly to forest-fires, but chiefly to the arrival of the Maoris, who doubtless lived upon them as long as any remained.

The giant Edentata of South America may have gradually succumbed to *local* floods, from which their terrestrial habits and their bulk afforded them no escape, whereas their smaller relatives, perhaps, by greater activity and arboreal habits, may have survived.

The gigantic Irish Deer may well have perished, in its final insular and limited home, from wolves, or wet seasons, which the altered land-conditions, due to the subsidence of the Irish Sea-valley (once dry land), may have brought about.

Be the causes what they may, it appears to us most unphilosophical to attempt to connect the extinction of all these animals, living in such widely-separated countries, with *one* overwhelming *debacle*, and to denounce the followers of uniformitarianism and condemn their tenets as unsound, yet at the same time to offer a universal deluge as the sure, safe and only panacea for all Pleistocene geological difficulties!

So nearly do the author's researches and results approach the subject of what is usually termed the Universal or Mosaic Deluge, that he is quite right to express his views as to the propriety of leaving the Biblical account alone; he tells us that it is not worth being measured by scientific forms of thought, and quotes Bacon and Sedgwick with appositeness, as to "the impossible task of equating science and faith."

"This vanity merits castigation and reproof the more, as, from the mischievous admixture of divine and human things, there is compounded at once a fantastic philosophy and a heretical religion"[1]

As to the extreme views maintained by some Glacialists we happily have nothing in common, and we gladly leave them to controvert Sir Henry Howorth's objections as best they can. (In matters of *argument* we notice that Sir Henry generally gets the best of his opponents!) Their condition in our opinion is very similar to that of the believers in the permanence of continents and oceanic basins. These are but the *fashions* of geology, "they have their entrances and exits," its *facts* are what we are most careful to gather, let those theorise who will! *Magna est veritas, et prævalebit.*

III.—Beiträge zur Geologie und Palæontologie von Sudamerika. 1. Palæozoische Versteinerungen aus Bolivien von Dr. Arnold Ulrich. Neues Jahrbuch für Mineralogie, etc. Beilageband viii. 1892, pp. 116, pls. i.–v.

Contributions to the Geology and Palæontology of South America. 1. Palæozoic Fossils from Bolivia. By Dr. A. Ulrich.

THIS memoir is intended as the first of a series of sketches on the geology and palæontology of South America, based on the observations and collections made by Prof. G. Steinmann, who in a brief introduction gives an outline of the route followed during his late expedition to that Continent. With the exception of a few poorly-preserved Silurian fossils, Dr. Ulrich's memoir consists of a description of a comparatively rich and well-marked fauna of Devonian age, mainly obtained from the highlands of Eastern Bolivia—some of the rocks are now at an elevation of 4,500 mètres above the sea. The greater portion of this elevated country is built up of Devonian strata, which show two distinct series, of which the lower or Icla series principally consists of shaly beds reaching a thickness of 300 to 400 mètres; the higher portion of these, known as the '*Conularia*' beds, is by far the most fossiliferous. The higher series, the thickness of which is not given, is mainly of sandstone and is known as the Huamampampa sandstone. Fossils have been found only in the lower beds of this series, and there is not a single species in common with the underlying Icla series.

The fauna in these beds includes various species of Trilobites, *Conularia*, *Hyolithus*, Gasteropoda, Lamellibranchiata, and numerous Brachiopods; in all, between 60 and 70 species, which have been carefully worked out and figured by Dr. Ulrich.

This fauna is purely Devonian in character, and it is chiefly remarkable for a strong resemblance to the Devonian fauna of the

---

[1] Sedgwick's paraphrase of Bacon, Ann. Address, Q.J.G.S., vol. xxii.

Eastern portion of the United States and Canada, and, what is still more strange, to that of the Cape region of South Africa, judging from the fossils collected by Bain and worked out by Salter and Sharpe; and also to the Devonian Fauna of the Falkland Islands discovered by Darwin and described by Morris and Sharpe. The author gives lists of the Bolivian species and of the corresponding species in the countries just mentioned, which show very distinctly the striking relationship of many of the fossils in these widely separated areas.

To give one or two examples from the brachiopoda: *Leptocœlia flabellites*, Conrad, sp., is a well known form in the Oriskany sandstone and Upper Helderberg of North America; it is very abundant in Bolivia, and the same species or a closely allied variety has been described from the Falkland Islands and from South Africa under the name of *Orthis palmata*, Morr. and Sharpe, whilst curiously enough, it is not recorded from Devonian rocks in other areas, and it is unknown even in the Devonian rocks of Brazil. *Tropidoleptus carinatus*, Conrad, sp. and *Vitulina pustulosa*, Hall, again, are two very distinctive species of local occurrence in the North American Devonian; they have a nearly similar distribution as *L. flabellites*, but the former occurs as well in Brazil, and is considered by the author to be the same as *Strophomena laticosta*, which is found in the Devonian of this country and other parts of Europe; whilst the latter species is restricted to N. and S. America and S. Africa, and is not found in any other region.

From a review of the whole of the fauna, Dr. Ulrich considers that the Icla shales correspond to the horizon of the Corniferous Group, and the Huamampampa sandstone to that of the Hamilton Group in the Devonian series of N. America. The Devonian beds both in S. America and in S. Africa appear to be shallow water deposits, and they resemble each other in the comparative rarity of Cephalopods and corals. The very striking facts relating to the distribution of these Devonian fossils which the author has brought to light in the present memoir, deserve the careful consideration of all interested in palæontology.

IV.—SVERIGES KAMBRISK-SILURISKA HYOLITHIDÆ OCH CONULARIIDÆ. Af GERHARD HOLM. With an English Summary. Sveriges Geologiska Undersökning. Ser. C. No. 112. Stockholm, 1893. ON THE HYOLITHIDÆ AND CONULARIIDÆ IN THE CAMBRIAN AND SILURIAN STRATA OF SWEDEN. By GERHARD HOLM. 4to. pp. ix. and 173, pls. i.–vi.

THE shells included in these two families have been generally ranked with the Molluscan order Pteropoda; but considerable doubt of their right to this position has been expressed by Pelseneer, one of the best authorities on recent Pteropods, who is unable to find any resemblance on which relationship could be based between the fossil forms and the existing members of this division. The author agrees with this view and apparently considers both these families as extinct and their systematic position uncertain, and he further points out that they are not in any way related to each other, so far as can be judged by the character of the shell; for whilst in the Hyolithidæ this is tolerably thick, not flexible, of at least three distinct layers, and mainly of carbonate of lime; in the Conulariidæ it is thin, apparently flexible, and mainly composed of phosphate of lime and chitinous material. Whilst in *Hyolithus* the shell is bilaterally symmetrical with a differentiated dorsal and ventral surface, in *Conularia* the shell is pyramidal, with a square or rhombic section, and with each side marked by a longitudinal median line known as the segmental line. A further difference is shown in the fact that *Hyolithus* is provided with an operculum and the aperture is not contracted, whilst in *Conularia* there is no operculum, and the upper portion or mouth of the shell seems to have been furnished with inwardly bending flanges.

Besides these two well-marked families, Dr. Holm proposes another—Torellidæ, based on *Hyolithus lævigatus*, Linnars., the shell of which is of phosphate of lime and thus resembles *Conularia*; but unlike this genus, it is elliptical in section, both sides of the shell are alike, and it is without other ornament than lines of growth. This form probably belongs to the Annelida, and the author also places in the same group the genera *Tentaculites* and *Salterella.*

In the family Hyolithidæ, the author only recognizes the single genus *Hyolithus*, Eichwald; but this may be divided into *Hyolithsu*, sens. str. and *Orthotheca*, Novak. This latter sub-genus includes the simpler original forms of conical shells with no other markings but lines of growth, in which the aperture is in a single plane and the operculum is a plane, or gently conical and without a semi-conical dorsal portion. In the higher developed *Hyolithus*, sens. str., the dorsal margin of the aperture has a semicircular extension, so that the aperture is formed by two planes meeting at an obtuse angle, and the operculum to fit this aperture, consists of a small lunate ventral portion and a larger semi-conical dorsal portion.

Of the other genera hitherto included in this family, *Camerotheca*, Matthew, *Diplotheca*, Matt. and *Pharetrella*, Hall, are brought within the type genus, whilst others, as *Coleoprion*, Sandb., *Coleolus*, Hall, *Clathrocœlia*, Hall, *Hemiceras*, Eichw. and *Hyolithellus*, Bill., are rejected as having no relationship with it; this latter genus is stated to be based on the brachiopod shell, *Discinella. Cleidotheca*, Salt., is founded on the assumption that some of the forms were destitute of an operculum, and *Centrotheca*, Salt., on a probable misinterpretation of the characters of the type form, *C. cuspidata*, Salt.

Through Dr. Holm's investigations the number of species of *Hyolithus* from the Swedish Cambrian, Ordovician (or Lower Silurian), and Silurian strata has been increased from 6 to 44; the greater portion of these are from Öland. From the Lower Cambrian or *Olenellus* region 7 species are recognized; from the Middle Cambrian or *Paradoxides* beds, 15 species; whilst they are scarcely at all present in the *Olenus* division. In the Ordovician or Lower Silurian, the *Endoceras vaginatum* region proved the richest, yielding 11 species all limited to it, whilst there are several related species in the higher *Lituites* region. In the *Chasmops* beds only a single species is definitely known, whilst the three species met with in the *Trinucleus* division belong to the sub-genus *Orthotheca*. From the Upper Silurian only three species were discovered by Lindström in the Isle of Gotland.

As regards the relationship of the Swedish forms of *Hyolithus* to those occurring in other countries, there is a considerable resemblance to those from North America, and the Lower Cambrian forms from that country described by Walcott correspond with those from the Middle Cambrian of Sweden. Owing to the imperfect preservation of the British species no comparison is practicable. There does not appear to be a single species in common with those from the Bohemian basin, though these latter are numerous and fairly well-preserved, and thus this group tends to confirm the evidence from the Trilobites, Gasteropods and Cephalopods that there was no direct connection between these areas at the period.

From a table giving in detail the references to the names, authors, and the distribution of the known species in the Cambrian-Silurian rocks, it appears that 55 species occur in the Cambrian, 68 in the Ordovician, and 22 in the Silurian series; and if to these are added 34 species from the Devonian, Carboniferous, and Permian rocks, the total number of species of this group reaches 178.

In the family Conulariidæ only the single genus *Conularia*, Miller, is recognised. The earliest known species is from the summit of the Cambrian in North America. The genus reaches its culmination in the Ordovician and continues apparently as far as the Lias. In Sweden there are 12 species from the Ordovician, 5 from the Silurian, and one common to both. Only one of these, *C. cancellata*, is common to the Bohemian basin and this species is widely distributed over the Continent of Europe, and probably is identical with *C. niagarensis*, Hall, from the Silurian of N. America.

As a rule the shell in these fossils is well-preserved, with the finest details of ornamentation, and the author has attempted a division of the genus into four groups, based on the surface sculpturing and the character of the segmental lines. In the first group, *Læves*, the shell exhibits only transverse wrinkles formed by the lines of growth, and the segmental line is depressed. In the second, *Longitudinales*, there are raised longitudinal ribs and the segmental line is elevated; in the third, or *Moniliferæ*, there are transverse ridges or rows of tubercles; whilst in the fourth, or *Cancellatæ*, the transverse main ridges are interrupted, and finer longitudinal ridges are likewise present.

The specific descriptions are accompanied by carefully drawn figures, showing the fossils and their surface characters enlarged, which thus greatly facilitate comparison with other forms. For the convenience of those to whom Swedish is unknown, the author has appended a short summary in English, giving a synopsis of the different species.
G. J. H.

V.—Description de la Faune Jurassique du Portugal. Mollusques Lamellibranches. Par Paul Choffat, Premier Ordre Siphonida Première Livraison. Pages 1 à 39 et Planches I. à IX. Lisbonne, 1893.

We do not appear to get much in the way of geology from Portugal, but what we do get is good. Here is another instalment of the description of the Jurassic Fauna by one whose previous contributions in the same direction have given us every confidence in their value. This particular section plunges at once *in medias res* and gives us a Monograph of the Jurassic *Pholadomyæ* of Portugal. The difficulties under which work is done in that country is curiously revealed by the few words of Preface, from which we learn that the text and plates were all ready in 1883, except plate i., which was intended to illustrate family matters, *i.e.* the families of *Pholadidæ, Myidæ*, and *Anatinidæ*; but the author had no artist at his disposition! Even now the plate is used, not as intended, but for new species of genera allied to *Pholadomya.* It is certainly a question whether this curious lack of artists is not a blessing in disguise, for the result is that the nine beautiful plates are all photographic representations, in permanent phototype print, of the actual specimens; nothing whatever in them is liable to the personal equation. This is, perhaps, specially advantageous in the case of such rough things as *Pholadomyæ*, where so much depends upon the shape, the strength, or otherwise, of the ridges, on the cardinal area and the character of the radiating ribs. And for another reason, as will be seen presently, it is a good thing to have as many figures as the author will give us of the Portuguese forms.

It appears that the Lias, at least, presents two distinct facies—one in which the succession can be fairly compared with that in Central Europe, and the other peculiar to the Iberian Peninsula. As several species of the *Pholadomyæ* occur in both, this should be an aid in correlation.

When, however, we come to examine this work in detail we get into a little difficulty. There always have been two types of Palæontologists: the one type divides and subdivides till almost every specimen is a species, and if there is any character common to them all, other than the one on which he has set his affections as the discriminator, they are said to show a remarkable "convergence," they are "homoplastic," "morphological equivalents," and all the rest of it. The other type seizes, perhaps, this very one of all the characters, as the bond of union into a "good species" of forms of which it may at least be said that if one gave birth immediately to the other the offspring would be considered a monstrosity. The one type also so subdivides the strata in which these fossils lie that the successive species must be as crowded in their "beds" as a family in a London slum; while the other gives his species so great an immortality that it crops up in formation after formation. Which of these two types will gain the ultimate victory, or whether both will be united or swept away by something more comprehensive, it is hard at present to say.

Meanwhile our author belongs to the second type. He describes all the previously known species of *Pholadomya*, ranging from the Lower Lias to the Kimmeridge, under 19 names, which include no less than 60 of those recognized by his predecessors, and of these *P. decorata* runs from the Lower Lias to the Inferior Oolite, *P. Murchisoni* from the Bajocian to the Callovian, and several others have nearly as wide a range; even these are said to show passages into each other, and the last named is said to be certainly the origin of *P. exaltata.* It is very probable that these two types of palæontologists represent two phases in the evolution of the geological knowledge of a country. In the earlier stages, when only an outline of the geology is known and the workers are few, it may be necessary to take a more general view; but as the details of the stratigraphy become familiar it is possible to come to closer quarters with the question of the succession of forms, and it is certain that the solution of this question can never be obtained without the most minute discrimination of varieties, while a correct one is impossible if in the midst of these details we lose sight of the wider laws.

As a sort of appendix we have descriptions of *Arcomya* and *Goniomeris,* a new genus, and it is a curious thing that all the species in these two genera are described as new. This part was written later. If species are taken in as wide a sense here, as the author does in the genus *Pholadomya*, one fancies one could match some of these amongst old Corallian friends. Has the author's idea of species become more limited in the interval? J. F. B.

VI.—The Iron-ores of Great Britain and Ireland, their Mode of Occurrence, Age, and Origin, and the Methods of Searching for and Working them (with a notice of some of the Iron-ores of Spain). By J. D. Kendall, F.G.S. 8vo. pp. xvi. and 430, with Illustrations. (London: Crosby, Lockwood & Son, 1893.)

IRON may justly claim to be one of the most important of all the elementary substances, not only by reason of its vast economic value to mankind, but also from its distribution in rocks of all ages which build up the framework of our globe and it is probably equally widely distributed throughout the universe.

Its presence in the stratified deposits is indicated by their colouring, which is no doubt largely owing to this metal. Rusty-brown tints are due to hydrated peroxide of iron; brighter red tints, and sometimes darker stains, are due to anhydrous peroxide of iron; greenish colours are produced by the protosilicate, and bluish tints are imparted by bi-sulphide of iron.

Notwithstanding the immense abundance of iron in the earth's crust, *metallic iron,* in a more or less pure condition, is but rarely met with. Indeed, until of late years, it was believed that all, or nearly all, such metallic iron was of extra-telluric, or meteoric origin, with the exception of ferruginous metallic platinum. True meteoric iron usually, if not invariably, contains nickel, to the extent of 1 or 2 parts per 100 of iron, up to considerably larger amounts; the Pallas Meteorite, Siberia, containing nearly 11 per cent., and the Cape of Good Hope meteorite 15 per cent. of nickel. Although the Ovifak, Greenland, irons were at first considered to be true meteorites, subsequent investigations led to the detection of spangles and grains and lumps of iron inclosed in the eruptive rock itself, adjacent to the larger loose blocks of iron; so that it is possible that these masses of iron may have welled up with the igneous rock from some very deep-seated source of telluric energy, and that our own earth may, in its interior, possess a large supply of metallic iron in addition to the vast stores of oxides and sulphides distributed through its sedimentary crust.

The compounds of iron, with various other substances which constitute the ores of iron, are very numerous.

Of these, "hæmatite," the anhydrous peroxide, known as *red* hæmatite, is that most commonly used for metallurgical purposes. Its composition is iron 70, oxygen 30=100.

Hæmatite occurs in the Coniston Limestone (Ordovician) of Millom; and in West Cumberland and Furness in the Carboniferous series. "Limonite" (hydrous peroxide or brown oxide), Magnetite (peroxide and protoxide of iron) and "Siderite" (or "chalybite," carbonate of protoxide of iron) in the Devonian rocks of Cornwall, Devon and Somerset.

As one would naturally expect, with the development of our Coal-fields, the interstratified seams of clay ironstone of Coal-measure age were for a very long time, extensively worked in the South Wales Coal-field; in Shropshire and North Staffordshire, in Northumberland and Durham, and in the Glasgow Coal area, and elsewhere.

"Thirty-six years ago these rocks yielded four-fifths of the ore raised in Great Britain; but since the introduction of the more cheaply worked ores of the Secondary rocks, this proportion has been gradually reduced, until now these measures do not produce more than one-sixth of the total raised. Not only has there been this great relative fall, but there has been an absolute diminution in the production of clay-ironstone to the extent of about 5,000,000 tons per annum. Every year this source of supply becomes less important; the only districts at present raising any considerable quantity being North Staffordshire and Scotland" (p. 145). The following table gives the

COMPARATIVE AMOUNT OF ORE RAISED AND CONSUMED IN THE UNITED KINGDOM.

	Tons in 1855.	Tons in 1890.
From the Secondary Rocks	1,044,384	9,060,169
,, Carboniferous Rocks	8,478,860	4,838,977
,, Other Rocks	30,497	54,792
Total	9,553,741	13,953,938

"It is thus seen that the output from the Coal-measures has, during the time embraced in these tables, fallen about 46 per cent., whilst that from the Secondary rocks has increased nearly 900 per cent. (p. 201)."

"*Deposits in the Lower Lias.*—The only deposit of iron-ore in these rocks that have been worked up to the present time occurs at Frodingham, in North Lincolnshire. For a long time it was considered, and perhaps by some is still thought, to be the equivalent of the Cleveland main bed; but there is now not any doubt whatever that it is in a much lower geological horizon. It occurs in the zone of *Ammonites semicostatus*, which in Cleveland is about 480 feet below the main seam of ore, although at Frodingham it is only about 161 feet below the equivalent of the latter bed, owing to the south-easterly attenuation of the rocks as previously mentioned. The ore occurs in the form of a bed, with a gentle inclination towards the east. Its maximum thickness is only about 25 feet; but owing to its slight dip, combined with the level nature of the ground, its outcrop occupies a wide stretch of country."

The following section was obtained in sinking a shaft to the ore between Appleby village and the railway station:—

		ft.	in.	Zone of
	Limestone (Lincolnshire)	36	8	
UPPER LIAS	Blue Shale	34	4	
	Sandstone	1	11	
	Grey Shale	25	10	*Ammonites communis.*
MIDDLE LIAS	IRONSTONE (Cleveland Main Seam)	7	10	*A. spinatus.*
LOWER LIAS (upper part only).	Shale with cement stone nodules ...	67	6	*A. capricornus.*
	IRONSTONE (Pecten bed)	4	6	*A. armatus.*
	Blue Shale	89	9	*A. raricostatus.*
	IRONSTONE (Frodingham main bed)	22	6	*A. semicostatus.*

This is followed by a careful and elaborate description of the "Cleveland Ironstone" from which more ore is raised in England than from any other formation.

The main seam of Ironstone is the only one that has been wrought extensively, though a lower seam has been worked in one part of the district.

The main seam has been proved to extend over a very large area, probably exceeding 350 square miles; but the area over which it can be profitably worked at present is much less (p. 213).

Then follows a description of the Caythorpe Ironstone; the Ironstone of Holwell, Leicestershire; the Oxfordshire Ironstone; with sundry smaller deposits.

The Northamptonshire Ironstone is next described, with its interesting series of fossil-remains, made known by the labours of the late Mr. Samuel Sharpe, F.G.S., formerly of Dallington Hall, near Northampton. From thence the author takes us to Seend, in Wiltshire, etc.; and lastly to the Iron-ore deposits of Ireland.

The practical and commercial parts of Iron-ore industry occupy parts iii. and iv., but space does not permit us to dwell upon them here.

We have said sufficient to show that Mr. Kendall is a thoroughly practical, painstaking, careful and efficient guide to the student (whether young or old) who desires further information on the mode of occurrence and places where Iron-ore industries are being carried on, and he may be trusted to guide aright.

Every section is accompanied by a list of all the more important authorities who have written upon the special branch of the subject, and the diagrams and tables are clear and carefully executed.

The book is sure to make its way with practical miners and students as a handy book of reference.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 7th, 1893. — W. H. Hudleston, Esq., M.A., F.R S., President, in the Chair.—The following communications were read:

1.—"The Bajocian of the Sherborne District: its relations to Subjacent and Superjacent Deposits." By S. S. Buckman, Esq., F.G.S.

This paper is partly the result of excavations made by Mr. Hudleston, F.R.S., and the author at Sherborne, to determine the position of the so-called '*Sowerbyi*-zone.'

The author uses the term 'Bajocian' in a merely conventional sense to denote the lower beds of what has been called 'Upper part of the Inferior Oolite.' He introduces a term emar (ἦμαρ) as a chronological subdivision of an 'age,' and considers the beds dealt with in the paper to have been deposited during 12 emata, which he calls, in descending order, *fuscum, zigzag, Truellii, Garantianum, niortense, Humphriesianum, Sauzei, Witchellia* sp., *discites, concavum, bradfordense,* and *Murchisonæ.*

A line from Stoford, Somerset, through North Dorset to Milborne Wick, Somerset, is the base-line of the district reviewed. Seventeen sections of places close to this line are given to show the relations of the beds, with the different amounts of strata deposited during successive emata, and during the same emar at different places. By means of Tables he shows that the area of maximum accumulation receded eastwards in the earlier emata, and then proceeded westwards during the later emata. A similar and corresponding faunal recession and progression is pointed out, though the faunal headquarters always remain west of the great accumulation of deposit. Adding the various maximum deposits together, the author finds as much as 130 feet of strata deposited during the twelve emata, = (practically) the 'Inferior Oolite of Dorset.' This is a far greater thickness than has hitherto been allowed to beds of this age in the district, but the fault lay partly in incorrect correlation.

The Dorset strata are correlated with strata in other districts—namely, with those of Dundry and Leckhampton Hills in this country. Of these the author gives sections, pointing out the emata during which the strata of those localities were deposited, and making some alterations in their correlation.

Passing to Württemberg, the author shows that the equivalent of Waagen's *Sowerbyi*-zone is exactly represented at Sherborne. Returning to Normandy, the author compares his results with the recent work done by Munier-Chalmas, who in some respects has made an even more detailed subdivision of the strata. In a Table he shows the correspondence between his divisions for Dorset and those of Munier-Chalmas in Normandy and Haug in Southern France.

2. "On Raised Beaches and Rolled Stones at High Levels in Jersey." By Andrew Dunlop, M.D., F.G.S.

In this paper the Author gives some account of the higher raised beaches examined by him on the south-eastern and eastern coast, but probably found in other parts of the island also, as indicated by the existence of rolled stones, etc. These beaches seem to prove submergence (in the case of that at South Hill, to a depth of at least 130 feet below the present level) at the end of the 'first glacier period.'

The brick-clay often lying on raised beach, and containing pebbles, has been compared to loess by the author. He believes that Prof. Prestwich's theory of sudden and rapid upheaval, with a resulting tumultous sweep of water, may be applied to Jersey; but also, if the sinking took place at the end of the Glacial Period, the peculiar conditions produced by melting ice may have played their part in producing the brick-clays.

Subsequent upheaval above the present sea-level is indicated by submerged forests, sometimes lying on the brick-clay.

No fossils have hitherto been found in the raised beaches; but a bone of *Bos primigenius* (?) has been extracted from the brick-clay.

II.—June 21st, 1893.—Dr. H. Woodward, F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "On composite Dykes in Arran." By Prof. J. W. Judd, F.R.S., V.P.G.S.

It is proposed to apply the term 'composite dyke' to any fissure which contains two or more distinct varieties of igneous rock, differing from one another in chemical composition or mineralogical constitution. Such dykes, it is shown, fall into two classes:—

(A) Dykes in which differentiation has evidently taken place in the materials after their injection, as in the examples described by Dr. Lawson in Canada and by Prof. Vogt in Norway.

(B) Dykes in which we have evidence of the re-opening of the fissure after its first injection and the introduction of materials of totally different composition. It is this class of dykes of which we find such interesting illustrations in Arran.

These Arran dykes belong to the latest volcanic eruptions of the British Islands; their analogues are found alike in the South of Scotland, and in the North of England and of Ireland. They are the infilled fissures along which sporadic volcanic outbursts took place after the extinction of the great volcanoes of the Inner Hebrides. The subaerial products of these later, and, for the most part, insignificant volcanic eruptions, have been all swept away by denudation, except at Beinn Hiant and the Sgúr of Eigg.

The materials filling these dykes belong to two totally different classes,—one distinctly basic, with about 55 per cent. of silica; and the other markedly acid in composition, with from 65 to 75 per cent. of silica. The basic rock is an augite-andesite, which passes sometimes into an intersertal and occasionally into an ophitic dolerite (tholeite and diabase); the glass of this rock shows a great tendency to separate from the phenocrysts. The acid rock is often a highly vitreous material ('pitchstone' or 'pitchstone-porphyry') which by devitrification passes into various forms of felsite and quartz-felsite. These rocks, if we class them according to the nature of the porphyritic minerals they contain, fall into the several groups of vitrophyric and trachytoid lavas, to which the terms pantellerite, quartz-pantellerite, rhyolite, andesite, and dacite have been applied. The glassy groundmass in the whole of these rocks, however, is always abundant, and its characters are remarkably uniform however much the phenocrysts may vary.

An admirable type of the Arran composite dykes is found at Cir Mhor; this dyke traverses the granite, and has been excellently described by Ramsay and Bryce. The sides of the dyke are composed of augite-andesite, having a specific gravity of 2·71 and a silica percentage of 56; the centre of the dyke consists of a quartz-pantellerite with glassy base ('pitchstone-porphyry') passing into various stony varieties: this acid rock has a specific gravity of 2·36, and contains from 72 to 75 per cent. of silica, it is rich in soda as well as potash, and yields much water. The acid and basic rocks are strikingly contrasted with one another, alike in the characters of all their porphyritic crystals and of their vitreous bases. The acid rocks, however, contain a few crystals which have evidently been derived from the basic rock.

There is one fact with respect to the acid rock of the Cir Mhor dyke, to which attention is now called for the first time. Hyalite, the clear form of opal, occurs in it as a rock-constituent, and forms globules made up of several concentric layers which envelop the grains of quartz, are moulded on the angles of the felspar-crystals, and sometimes form independent segregations, with nuclei of tridymite-crystals. The identity of this interesting mineral has been established, not only by its optical properties, but by various microchemical tests.

On the shore and in the cliffs at Tormore, on the west coast of Arran, there occurs a remarkable plexus of dykes, many of which supply striking illustrations of our second class of 'composite dykes.' The locality was first described by Jameson, and some of the dykes have since been noticed by Allport, Zirkel, and other authors. In these composite dykes both the basic and the acid rocks are present; but while in some cases the acid rock was clearly introduced after the basic, in others the order of ejection of the two materials was reversed. In some instances, the plane of weakness along which the opening and re-injection of the dyke took place follows its central line; at other times it is at the side of the dyke; and occasionally it traverses the dyke-mass in a sinuous manner. The younger rock often contains numerous crystals derived from the older one, and these often show much alteration from the action of the magma in which they have been caught up. It is evident that the interval between the first and second injection of these dykes was sufficiently long to allow of the complete consolidation of the older rock

In conclusion, it is pointed out that, while the peculiarities of the first class of composite dykes can be accounted for by selective crystallization and liquation going on within the magma which has been injected into the dyke, no such explanation is sufficient in the case of the composite dykes of the second class, to which the examples cited from Arran belong.

That the association of two totally different rocks in the same dyke is not accidental, the numerous and varied examples at Tormore sufficiently prove. Where, as in these cases, we find that there is the greatest dissimilarity between both the crystals and the glassy groundmass of the two rocks, it is clear that the differentiation has taken place in the magma, prior to its injection into the dykes, and before the work of crystallization had commenced. The physical causes which have been suggested to account for such differentiation in a fluid mixture of silicates are discussed.

2. "Notes on an Intrusive Sheet of Diabase and Associated Rocks at Robin Hood, near Bassenthwaite." By J. Postlethwaite, Esq., F.G.S.

The positions of the outcrops of the igneous rock are described, and a grit-band is recorded as running parallel to the diabase. The diabase, and vein-stuff associated with it, have furnished antimony, lead, copper, and arsenic; and the same ores, with the exception of the last two, are also found in minute grains in the grit. Analyses of the grit and diabase, made by Messrs. Hellon and Brockbank, are given. Prof. Bonney has examined slides submitted by the author, and has allowed the use of his notes in the paper. The igneous rock has produced slight metamorphism in the surrounding rocks of the Skiddaw Slates.

3. "On Two Dinosaurian Teeth from Aylesbury." By R. Lydekker, Esq., B.A., F.G.S.

Two teeth from the neighbourhood of Aylesbury, believed to be of Portlandian age, may be referred to the same species as is a tooth figured by De La Moussay from the Portlandian of Boulogne. The Aylesbury teeth are described in the paper, and the nature of the animal which possessed them is discussed.

4. "On a New Plesiosaur from the Waipara River, New Zealand." By Capt. F. W. Hutton, F.R.S., F.G.S.

This specimen was shortly described by Sir James Hector in 1873. The author considers it more prudent to follow Mr. Lydekker in referring all the known New Zealand Cretaceous Sauropterygians with which he is acquainted to Leidy's genus *Cimoliosaurus*, and he therefore describes this form as a new species of that genus.

5. "Observations on the Affinities of the Genus *Astrocœnia*." By Robert F. Tomes, Esq. F.G.S.

Researches recently made by the author relative to the structure of certain undoubted *Astrocœniæ* of the Gosau beds, having for their primary object the better understanding of the supposed species of the genus obtained from the Glamorganshire conglomerate, have been productive of results which will render a complete modification in the classificatory position of the genus imperative.

The author gives a new definition of the genus, in which he does not at present include any species of an earlier date than the Cretaceous period, all the so-called Jurassic *Astrocœniæ* being referable to other and quite distinct genera.

6. "Description of a new Genus of *Madreporaria* from the Sutton Stone of South Wales." By Robert F. Tomes, Esq., F.G.S.

In the Quarterly Journal for 1885 is a detailed description of a coral from the Sutton Stone named *Astrocœnia gibbosa.* This specimen is not the type of the species, and a re-examination of it by the author has proved that it is not an *Astrocœnia.* Two other specimens have also been examined, and as a result of examination of the three the author is enabled to found a new genus *Styloseris,* of which a diagnosis is given, and the specific name *gibbosa* is retained for this, the only known species. The genus will take its place near *Clausastrœa,* from which it differs by possessing a well developed columella and increasing by both fissiparity and gemmation.

7. "Study of the Dykes of Hope, Idaho." By Herbert R. Wood, Esq. Communicated by the President.

In this paper a description of the geographical distribution and characters of acid and basic dykes traversing slates and quartzites along the northern shore of Lake Pend'Oreille, Idaho, is accompanied by notes on the glaciation of the area. A brief description of the microscopic features of the igneous rocks is appended.

8. "The Rise and Fall of Lake Tanganyika." By Dr. Robert Sieger. Communicated by the President.

The author refers to Mr. Carson's paper on the same subject in the Society's Journal for 1892. He himself believes the oscillation of level to be analogous to variations reported as occurring in other African lakes, and to be due to climatic change. He brings forward evidence in favour of the coincidence of change of level and climatic change, but does not believe that his views are by any means contradictory to those of Mr. Carson, for the phenomena may be explained by a combination of the influences of climate with those of mechanical agencies.

9. "On Cheilostomatous Bryozoa from the Middle Lias." By Edwin A. Walford, Esq., F.G.S.

The author describes some forms of bryozoa from the *spinatus*-zone of the Middle Lias near Banbury, some of which had previously been classed with the Cyclostomata. The new material not only shows the opercular aperture but the opercula *in situ,* together with appendages and supra-oral ovicells characteristic of the Cheilostomata. In addition he has also found giant cells (cistern cells) of form quite dissimilar from the ordinary zooecia and probably reproductive. He cites M. Jules Haime as having described in his magnificent monograph somewhat similar cells from the Inferior Oolite; and in the Oxfordshire Great Oolite Bryozoa Mr. Walford has found cistern-cells like the Lias species on some colonies like *Diastoporæ.* He contends that it is merely the acquisition of very well-preserved material which is needed to show the necessity of removal of many such species to the Cheilostomata. The name *Cisternophora* is suggested for the genus, of which several forms are described.

The next Ordinary Meeting of the Society will be held on Wednesday, November 8th, 1893.

AN UNFAMILIAR RAILWAY DANGER.

SIR,—In a short paper by Mr. Griesbach, C.I.E., of the Geological Survey of India, which appears in the Records of that Survey for May, 1893,[1] we learn that both lines of rails of the frontier section of the North-Western Railway, near the Station of Sanzal, in the neighbourhood of the Kójak Range, in Balúchistán, became violently distorted where crossed obliquely by a line of fissure which was caused by the earthquake of the 20th of December last. The first and most severe shock occurred at 5.40 a.m., but several others recurred at frequent intervals during that day and the two following. Photograveur illustrations of the scene showing the deflection of the rails, as well as a plan to scale, are given, from which it appears that the curvature of both pairs of rails, within a length of from 30 to 40 feet, shifted them more than the width of the track in each case, the curves being so sharp that any train passing along the lines in the dark, or without the occurrence being noticed or looked for, must have been wrecked. Buildings suffer more from earthquakes than Railways, still, these earth-movements are not so uncommon that Railway Companies should neglect the hint given by the occurrence. A. B. W.

OBITUARY.

THE REV. HENRY HUGH HIGGINS, M.A.

BORN 28 JANUARY, 1814; DIED 2 JULY, 1893.

THE City of Liverpool has sustained a great loss in its intellectual life, by the death of the Rev. H. H. Higgins, M.A., who for more than forty years has devoted himself to the advancement of Natural Science in the midst of one of the busiest communities in England.

Born at Turvey Abbey, Beds, on January 28, 1814, he entered Corpus Christi College, Cambridge, in 1833, and took his B.A. degree in 1836. He was admitted to priest's orders in 1839, and devoted four years to clerical duty in the town of Wolverhampton, proceeding in the following year to Shrewsbury. Mr. Higgins came to reside in Liverpool in 1842, and occupied himself with more congenial educational work, being made Inspector of the Schools of the Church of England School Society, a position which he resigned in 1848, though, as Hon. Secretary, and afterwards Hon. Treasurer, he retained connection with the Society. After performing other church duties, he was appointed Chaplain to the County Asylum, Rainhill, in 1853, which post he continued to hold until 1886. A long Eastern tour through the Holy Land and Egypt was undertaken in 1848, and described in a course of six lectures given at the Liverpool Collegiate Institution, the proceeds of which—amounting to £300—Mr. Higgins generously gave to the School Society. In 1876 he accompanied Mr. Reginald Cholmondeley in his steam yacht, the "Argo," on a voyage to the West Indies, which Mr. Higgins has charmingly described in a small 12mo. volume entitled "Notes by a Field Naturalist in the Western Tropics." Valuable collections of natural history specimens, now interspersed in the series exhibited in the Liverpool Free Public Museum, resulted from the voyage. This Museum is largely indebted to Mr. Higgins's labours. For a long series of years he has acted as Chairman of the Museum Sub-Committee of Management, and he has besides devoted many hours weekly to the classification and arrangement of the collections in the possession of the city. In connection with this institution Mr. Higgins is the author of three useful handbooks, viz.—a "Synopsis of the Invertebrata," a "Museum Memorandum Book," and a popular pamphlet entitled "Museum Talk," of which more than 25,000 copies have been sold at a nominal price in the Museum buildings. He has also published an essay on "Museums of Natural History" (contributed originally to the Literary and Philosophical Society of Liverpool, which is replete with practical suggestions on museum management and appliances. "The most important function of a museum," states our author in this work, is not so much to instruct as to win and encourage minds to get themselves instructed through habits of observation." One of the most valuable collections in the Museum is a fine series of Coal Measure fossils, collected by Mr. Higgins himself from a railway cutting at Ravenhead, near St. Helens. In 1880 he was fortunate in securing for the Museum a numerous series of Cirripedes collected in the "Beagle" by Charles Darwin. These were duplicates remaining after Mr. Darwin had (as he states in a letter to Mr. Higgins) made the British Museum collection as perfect as he could. The system of circulating boxes of museum specimens for use in schools was also originated by him. On more than one occasion Mr. Higgins has received from admirers of his work testimonials showing how greatly his labours have been appreciated.

---

[1] This paper has only just come to hand since the writing of Mr. C. Davison's article, see *ante* pp. 356–360.—EDIT. GEOL. MAG.

Mr. Higgins founded, in the year 1860, the Liverpool Naturalists' Field Club, of which he was President to the last; and he has also occupied the presidential chairs of the Literary and Philosophical and Microscopical Societies of Liverpool. His contributions to the published "Transactions" of these Societies, besides those of other similar associations, have been exceedingly numerous. They will be found conveniently collected in three 8vo. volumes, under the title of "Opuscula," in the Free Public Library of Liverpool. The papers contained in these volumes range in date from 1855 to 1887, and deal with a variety of scientific subjects in a light and pleasing, yet instructive manner. In all his writings, Mr. Higgins is a true exponent of the "poetry of science," which is far too often neglected in our modern haste for the rapid acquirement of knowledge—so characteristic a feature of the age in which we live.

With him originated the idea of sending out preserved specimens of various classes of creatures to form the subjects of lessons in elementary zoology and botany for schools. This commenced in 1884, and in the interval, the technical education scheme having been introduced, these specimens have been found exceedingly useful, especially as every one of them bears attached a few short notes indicating the outline of a lesson which the teacher has to prepare. Proceeding further in this direction, Mr. Higgins quite recently projected a popular mineral collection to show how things dug out of the earth are rendered useful to man by being passed through various processes. Thus iron was to be seen in several stages, from the ore to the manufactured article. The introduction of mechanical models into the course of school lessons was also one of his ideas, and this was admirably carried out, notably by the "model clock" (made for him by Mr. George Eccles, clockmaker), which can be taken to pieces and put together again by the fingers, without the aid of tools. This clock is sent to the elementary schools whenever required, and when not so in use it stands in the vestibule of the Museum. He also strongly advocated the use of the lantern and limelight in illustrating lectures and lessons.

So deeply did he feel the importance of a museum as an institution which should be extended and rendered as complete and useful as possible, that he gladly took part in organising the Museums' Association, which held its first regular meeting in Liverpool in June, 1890, and, having been chosen the first President, he delivered the inaugural address, in the course of which, after having dealt with the general subject of natural history museums and their appliances, he went on to speak of "The New Knowledge." "As members," he said, "of our museum fellowship we are bound to be more or less familiar with the scientific side of the new knowledge, and must have felt the magnitude of the revolution it has brought about. It has an equally potent moral side, from which I will ask you to consider an inference fraught with encouragement for the future. The new knowledge leads to the conclusion that the most exalted productions ever brought forth in poetry, philosophy, or science were not obtained otherwise than in the orderly course of results which had gone before. Shakespeare could not have lived 100 years before his time. His life was not a miracle, except as having its share in that ever-energising and enduring life-miracle in the presence of which we stand silent with bowed heads. Galileo, Bruno, had their times prepared for them, and in their turn prepared the way for Faraday, Agassiz, Darwin. Nor is there in our own days even the least indication of an approach to finality; gravitation, electricity, life are unknown essences. In biology some of the most illustrious discoveries still exhibit crudities and incompleteness removing them beyond a measurable distance from perfection. Were they, then, not discoveries? Assuredly they were; and in spite of all imperfections they are the glory of our times. But what we claim for our own knowledge we must grant to the attainments of our predecessors, admitting freely that there may be great good and even great glory in a very imperfect stage of knowledge, if it be that which is best fitted for its environments. This we have been slack in perceiving, because we have not realised how vast, how unique a thing has been the flow of knowledge from age to age. Take the knowledge of any age: it is a goal; it has been tended towards and reached by the efforts and successes of many former ages: it is a terminus, long forecasted, towards which the steps of followers have been unconsciously directed, rendering it more and more accessible as generations came and went." So much interest did Mr. Higgins manifest in the success of the Museums' Association that he constantly attended its meetings, and it had been arranged that he and Mr. Paden, the acting curator at the William Brown Museum, should proceed to London on the 3rd July to attend a meeting of the Association there, commencing on Monday evening. This journey was agreed upon no later than on the 1st July, when, after listening to Mr. Best's organ recital, Mr. Higgins crossed over to the Museum, as was his usual custom almost daily.

The officials and employés at the Museum and Free Library received the news of his death with profound regret. Not being a member of the City Council, he could not be elected chairman of the Library, Museum, and Arts Committee, but some years ago he was appointed Chairman of the Sub-Committee of the Museum and Mayer Collection, and continued in that office till the last. It is almost needless to say that his literary attainments were of a high order, and that he was one of the most valued members of the Library Committee when books new or old came to be selected.

Mr. Higgins, who was in his eightieth year, had been in his usual health on Sunday, 2nd July, and proceeded to his library, as was his wont, in the evening, where his retirement was not broken, and was permitted to remain undisturbed for some time, but on his study being entered about nine o'clock Mr. Higgins was found by one of his sons sitting at his writing-desk, surrounded as usual with his books and papers, but quite dead. The circumstances of his death seemed, one would think, an appropriate close to a life the remarkable industry and activity of which has aided so largely in the advance of scientific progress and educational culture and has left no time for idleness. It was known to the family that he had intended to proceed on Monday, 3rd July, to London, to attend the Meeting of the Museums' Association, at which he had undertaken to read a paper entitled "On a Public Museum Series of Minerals arranged in aid of Technical Education." The manuscript found on his writing-desk immediately in front of him showed that he had been busily engaged on that very work. Several folios of it had been written, and its sudden stoppage in the middle of a word indicated that the attack had proved at once fatal.

With the Literary and Philosophical Society of Liverpool Mr. Higgins had been connected for forty-six years, and he had twice filled office as its President.

Mr. Higgins was also intimately identified with the Naturalist's Field-club, another society connected with the Royal Institution, and he had been its President for many years, and a constant attendant at the field meetings. He was also identified with the Microscopical, and other scientific societies held in Liverpool.

On the death, in 1885, of his brother, Charles Longuet Higgins, of Turvey Abbey (the "Good Layman" in Dean Burgon's "Lives of Twelve Good Men"), Mr. Higgins succeeded to the manor of Turvey and the family estates in Bedfordshire and Buckinghamshire.

Although he will be long remembered and much missed in connection with the societies already named, the work which he accomplished in connection with the Free Library and Museum, on the committee of which he was a member for about thirty-three years, will probably in future years be regarded as the chief monument to his memory. His labours in reference to the Museum commenced really about seven years before he became a member of the committee, in November, 1859, as a representative of the Derby Trustees, his scientific knowledge, of which the late Sir James Picton had a very high opinion, pointing him out as probably the best-equipped gentleman in Liverpool to assist by his advice in extending the scope of the Institution, which was then at its commencement, and which has since become so famous. His labour in the Liverpool Museum for the past forty years may therefore be truly described as a labour of love. In the classification and arrangement of the specimens he took an active part in conjunction with the chief curator, the late Mr. T. J. Moore, the two officials making a general division of the work, Mr. Moore attending chiefly to the vertebrates, and Mr. Higgins to the invertebrates, each rendering the other the most ready assistance, and working in perfect harmony to the last, Mr. Moore having passed away only a few months ago. With an eye to the practical as well as the strictly scientific uses of the Museum, Mr. Higgins conceived the idea of exhibiting the specimens in so simple a manner that people of ordinary education could appreciate them, and to that end he compiled the well-known little book entitled "Museum Talk about Animals which have no Bones," and which was intended and has been extensively used as a "Visitors' Companion" to the Museum. That the pamphlet has become popular may be gathered from the fact that 36,000 copies have been issued in six editions.

Rarely could anyone retain, as Mr. Higgins did, for nearly eighty years, that earnest craving for increased scientific knowledge, combined with a child-like simplicity and sweetness of disposition which endeared him to his friends and attracted all young people to him from far and wide.

He was a keen musician, and his love of harmony pervaded all his scientific pursuits, and added a charm to his home-life, and to the wider circle of those who knew and appreciated him for his many personal merits, as well as for his devotion to the public service.

ERRATA: GEOLOGICAL MAGAZINE, JULY, 1893.

Readers are requested to make the following corrections in Prof. V. Ball's article on "Barren Island."

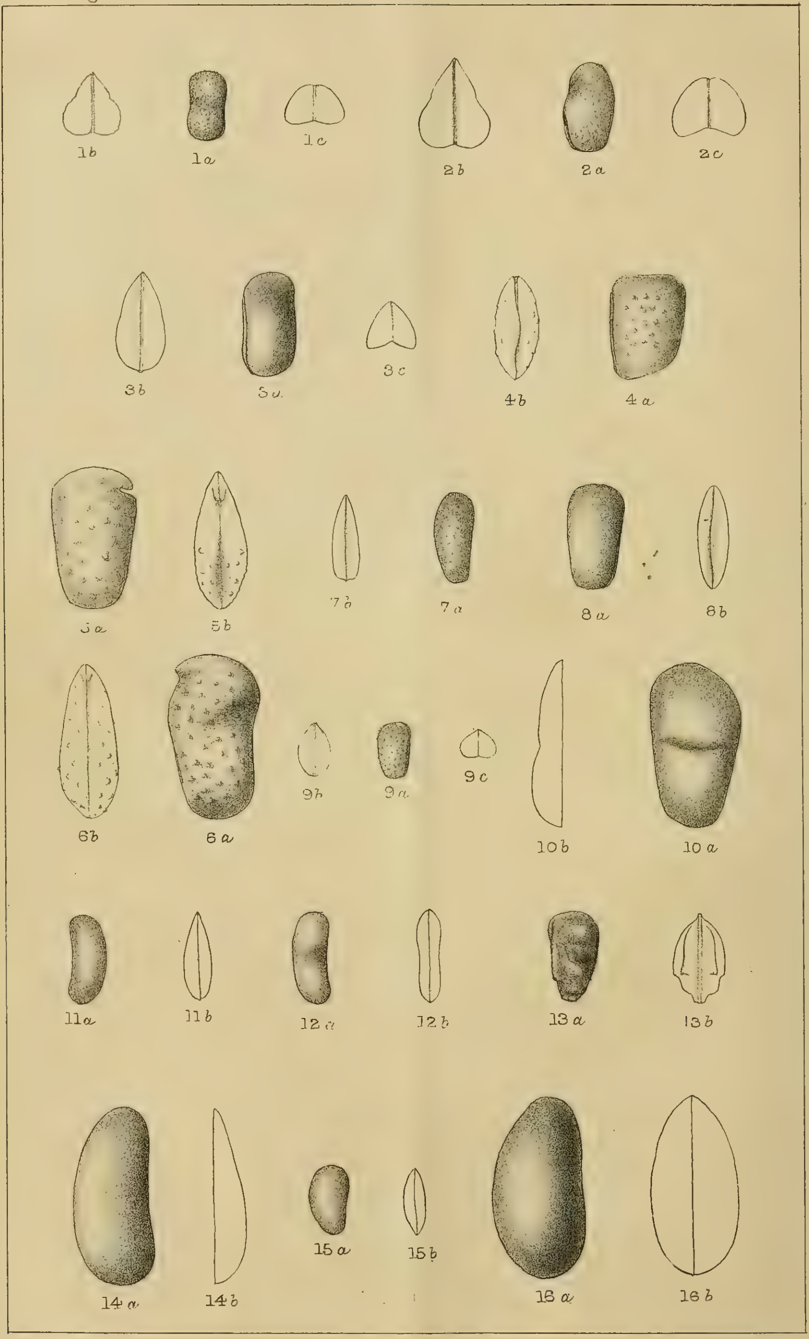
p. 290. Note 1., for *Rhyticiros*, read *Rhyticeros*.
p. 291. line 10, for "Prince," read "Prine."

In *re* "New Classifications of the Brachiopoda," GEOLOGICAL MAGAZINE, July, p. 318, third line from bottom, for *Neotremata*, read *Protremata*.

The *Telotremata* originated from the pentameroids of the *Protremata*, as is correctly indicated by Mr. Schuchert on his Table V. and p. 145, "American Geologist," vol. xi. No. 3, while on a subsequent page (147) he states "The *Telotremata* had their origin in the *Neotremata*"! The first statements are correct, but the fact is the ordinal characters converge the farther we go back in geological times, and what better proof can we have of the evolution of the Brachiopoda? Mr. Chas. Schuchert is now attached to the National Museum, Washington, D.C., U.S.A.

AGNES CRANE.

On p. 336, line 6 from bottom, for "Gygomatic," read "Zygomatic."



E.C. Knight lith.
West, Newman imp.

Fossil Ostracoda from S.W. Wyoming and Utah.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. IX.—SEPTEMBER, 1893.

ORIGINAL ARTICLES.

I.—On Some Fossil Ostracoda from S.-W. Wyoming, and from Utah, U.S.A.

By Prof. T. Rupert Jones, F.R.S., F.G.S., Etc.

(PLATE XV.)

Contents.

§ 1. Introduction.
§ 2. Description of the Species.
  1. *Cypris Purbeckensis*, E. Forbes.
  2. *Cypridea tuberculata* (Sow.), var. *Wyomingensis*, nov.
  3. *Potamocypris affinis*, sp. nov.
  4. ——— *unisulcata*, Jones.
  5. *Candona subreniformis*, sp. nov.
  6. ——— *subovata*, sp. nov.
  7. *Metacypris subcordata*, sp. nov.
  8. ——— *consobrina*, sp. nov.
  9. ——— *cuneiformis*, sp. nov.
  10. ——— *simplex*, sp. nov.
  11. *Cythere monticula*, sp. nov.
  12. *Cytheridea truncata*, sp. nov.
  13. ——— *tenuis*, sp. nov.
  14. *Cytherideis æqualis*, sp. nov.
  15. ——— *impressa*, sp. nov.

§ 1. *Introduction.*

In 1885 Dr. C. A. White, F.C.G.S., Palæontologist to the U.S. Geological Survey, supplied me with some of the siliceous residue of a limestone belonging to the freshwater Jurassic *Atlantosaurus*-beds in Colorado, from which several casts of small Ostracoda were figured and described in the Geological Magazine,[1] Dec. III. Vol. III. April, 1886, pp. 145–8, Pl. IV. Since that time Dr. White has kindly sent me somewhat similar material, obtained in like manner, by dissolving in dilute acid pieces of an impure limestone, which lies at the base of the Upper Cretaceous Series, from Cokeville, a hamlet in South-Western Wyoming, and belongs to the Bear-River Formation. The Ostracoda selected are figured in Plate XV. Figs. 1–9, 11–13, and 15. These casts represent the whole carapace in many if not all instances.

All the known fossils from the deposit yielding these specimens, Dr. White tells me, are either fresh-water or brackish-water forms (none marine). Of these under notice, however, Figs. 11 and 12 belong to a marine genus. The *Chara*, occurring abundantly with these fossils from S.-W. Wyoming, has been published by

---

[1] Also noticed in the "Bulletin U.S. Geol. Survey," No. 29, May, 1889.

Mr. F. H. Knowlton (in the "Botanical Gazette," vol. xviii. p. 141, figs. 1–3), as *Chara Stantoni.* It has much of the appearance of some of the *Charæ* found in the Oligocene beds of the Isle of Wight. Various species of *Pyrgulifera, Corbula, Unio, Limnæa,* and *Neritina,* are found as siliceous casts with the Chara.

Dr. White has also sent to me a piece of shale containing Ostracoda with their tests preserved, but very fragile; this specimen was from the Montana Formation, near the top of the Upper Cretaceous Series, at Coalville, Utah, about 40 miles from Salt-Lake City. Some examples are illustrated by Figs. 10, 14, and 16, belonging to brackish- or, more probably, fresh-water genera.

UPPER CRETACEOUS SERIES.	Laramie Formation.	
		<Place of the shale from Utah.
	Montana Formation.	
	Colorado Formation.	
	Bear-River Formation.	Place of the specimens obtained by dissolving the impure limestone from S.-W. Wyoming.
	Dakota Formation.	

Some of the specimens from S.-W. Wyoming, now figured, remind us of those from Colorado, above-mentioned; others are different; but nearly all appear to represent either freshwater or estuarine forms; and are thus in accord with the other known fossils of the Upper Cretaceous beds from which they have come.

The selected specimens are described in their natural order according to the classification of the Ostracoda.

§ 2. *Description of the Species.*

I. CYPRIS, Müller, 1785.

1. CYPRIS PURBECKENSIS, E. Forbes. Pl. XV. Figs. 15*a*, 15*b*.

Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 347–8, pl. 9, figs. 1–6.
Length ·5, height ·3, thickness ·15 mm.

Fig. 15*a* is referable to *Cypris Purbeckensis,* being like figs. 3–5 of those figured and described in 1885 (*op. cit.*); it is, therefore, evidently equivalent to figs. 5*a, b, c,* Pl. IV. GEOL. MAG. 1886, p. 147, illustrating the same form from Colorado.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

II. CYPRIDEA, Bosquet, 1852.

Quart. Journ. Geol. Soc. vol. xli. 1885, p. 336.

2. CYPRIDEA TUBERCULATA (Sowerby, *op. cit.* p. 342), var. WYOMINGENSIS, nov. Pl. XV. Figs. 5*a, b*; 6*a, b.*

Fig. 5. Length ·95, height ·6, thickness ·35 mm.
Fig. 6. ——— 1·05, —— ·6, ——— ·4 mm.

This comes very near to *Cypridea tuberculata* (Sow.), var. *adjuncta,* Jones (*op. cit.* p. 342, Pl. VIII. Figs. 22–24), but its antero-dorsal angle (anterior hinge) is stronger, giving a more pronounced slope to the dorsal border; its notch and hood are stronger; its tubercles are not so strong; the valves are not so convex, hence the edge-view is narrower. Some few individuals (figs. 6*a*, *b*, for instance) have a strong dorsal depression just behind the front hinge, and a deformation of the antero-ventral border. This furrow is irregular; but the largest example is figured here. Sometimes the depression consists of two narrow sub-triangular hollows. It is difficult to determine if this be a varietal character, or the result of accident or disease.

The original *Cypridea tuberculata* (Sowerby) is sub-quadrate and relatively shorter and thicker than either var. *adjuncta* or the form under notice. The latter is sufficiently distinct to have a varietal name—*Wyomingensis*

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

III. Potamocypris, Brady, 1870.

3. Potamocypris affinis, sp. nov. Pl. XV. Figs. 8*a*, *b*.

Length ·7, height ·4, thickness ·22 mm.

This is not far distant in shape from *Cytherideis* [?] *Marshii*,[1] Jones; but it is more oblong, being less attenuate posteriorly, and has not so great a lateral convexity.

Some of the fossil Ostracoda formerly referred to *Cytherideis* probably belong to *Potamocypris*; and I think that *C. Marshii* and the specimens now under notice should be regarded as belonging to this genus. I propose to name the present form as *P. affinis*. The species of this genus live in fresh and brackish waters.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

4. Potamocypris unisulcata, Jones. Pl. XV. Figs. 10*a*, *b*.

Length 1·05, height ·65, thickness ·45 mm.

The "*Cytherideis*" *unisulcata*, Jones, Monogr. Tert. Entom., Pal. Soc. 1856, p. 48, pl. iv. fig. 10, and Suppl. Monogr. 1889, p. 46, was regarded as a doubtful species; but (its proposed genus, *Cytherideis*, having been revised and limited by G. S. Brady and A. M. Norman, 1889) its right place is in *Potamocypris*. To this *P. unisulcata* the present species aptly coincides. Its transverse furrow is at first sight a differential characteristic; but we find so many genera having species impressed with a more or less distinct transverse furrow[2] that we cannot remove this form from *Pontocypris* on account of that feature.

P. unisulcata occurs in the green shale of the Osborn Series, Cliff End,[3] Isle of Wight, with *Candona Forbesii*, Jones, also *Paludina*, *Melanopsis*, *Melania*, *Lepidosteus* and remains of Alligator.

Fig. 10 is from the Montana Formation; Coalville, Utah.

---

[1] Geol. Mag. 1886, p. 147, Pl. IV. Figs. 6*a*, *b*, *c*.

[2] A more or less perfect furrow marks the valves in some species of *Cypris*, *Limnicythere*, *Cytheridea*, *Cythere*, *Cytheropteron*, *Bythocythere*, *Cytherella*, *Cypridina*. In the foregoing the sulcus is often rare and always irregular; but it holds good, however, more definitely as a generic character in the Palæozoic *Entomis* and *Entomidella*, although partially shown in some contemporary genera, especially *Primitia*.

[3] Mem. Geol. Surv., Isle of Wight, 2nd edit., by Reid and Strahan, 1889, p. 150.

IV. CANDONA, Baird, 1845.

5. CANDONA SUBRENIFORMIS, sp. nov. Pl. XV. Fig. 14 *a*, *b*.

Length, 1·2, height ·6, thickness ·5 mm.

This approaches the female form of *Candona Kingsleii*, Brady and Robertson (see Trans. R. Dublin Soc. ser. 2, vol. iv. 1889, p. 102, pl. ix. figs. 19, 20), in shape; but it is relatively fuller in the posterior third.

From the Montana Formation; Coalville, Utah.

6. CANDONA SUBOVATA, sp. nov. Pl. XV. Figs. 16*a*, *b*.

Length 1·2, height ·65, thickness ·65 mm.

Although subovate, almost subreniform, and with a low front, its lateral aspect is too long and narrow in proportion, and its edge view too thick for *Cypris incongruens*, *Ramdohr*,[1] nor has it the slight, flattened margin of that form.

So also it is not unlike *Cypris*? *Cambrica* (female), Brady and Robertson (Ann. Mag. N.H. ser. 4, vol. ix. 1872, p. 55, pl. ii, figs. 3, 4), except that it is fuller at the middle and posterior thirds, and more convex at the sides, so that in the broadly-lanceolate edge view the anterior extremity is not so sharp, and the posterior is quite blunt.

Among the figures of *Candona candida*, male and female, and its varieties, shown in the Trans. R. Dublin Soc. 1889, pl. x. figs. 14–23, figs. 18 and 19 (female) are somewhat like our fig. 16, but rather less plump, not so convex on the back, and too sharp at the ends in the edge view. Figs. 20 and 21, except that they project too much at the postero-ventral region, have a closer resemblance to fig. 16 than the foregoing; and I think it most probable that both fig. 14 and fig. 16 are referable to the same genus (*Candona*), but they differ specifically from any that I know.

From the Montana Formation; Coalville, Utah.

7. METACYPRIS SUBCORDATA, sp. nov. Pl. XV. Figs. 2*a*, *b*, *c*.

Length ·6, height ·35, thickness ·5 mm.

This *Metacypris* approaches the well-known recent *M. cordata*, Brady and Robertson,[2] especially the female form; but the transverse constriction more strongly impresses the lateral convexity, the dorsal region in each valve is more depressed and sloping, and the ventral region is more deeply excavated. The surface is marked with a shallow, irregular pitting, almost a reticulation.

The specific name, *M. subcordata*, is applicable, in allusion to its recent ally.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

8. METACYPRIS CONSOBRINA, sp. nov. Pl. XV. Figs. 1*a*, *b*, *c*.

Length ·45, height ·25, thickness ·4 mm.

This is evidently a *Metacypris*, and nearly allied to both *M. Forbesii*,

---

[1] Magaz. Ges. nat. Freunde zu Berlin, II. Quartal, 1808, p. 86, pl. iii. figs. 19, 20; also Brady, Trans. Linn. Soc. 1868, p. 362, pl. xxiii. figs. 16–22.

[2] See Trans. R. Dubl. Soc. n.s. vol. iv. 1889, p. 123, pl. xiv. figs. 3-12, for latest notice, by Brady and Norman.

Jones, and *M. Bradyi*, Jones (Geol. Mag. 1886, Pl. IV. Fig. 1 and Fig. 2); it is, however, smaller, relatively shorter, plumper, and less strongly constricted across the middle than *M. Bradyi*; and smaller, longer (relatively), and more oblong than *M. Forbesii*; its transverse sulcus, also, is quite medial, and not at the anterior third as in the latter. Being thus quite distinct, although related, it may have the new specific name of *M. consobrina*. The surface has a shallow, irregular pitting.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

9. Metacypris cuneiformis, sp. nov. Pl. XV. Figs. 3*a*, *b*, *c*.

Length ·65, height ·35, thickness ·3 mm.

Oblong; compressed anteriorly, convex behind; almost straight on the parallel dorsal and ventral borders, the former compressed and sharp, the latter deeply sunken, giving a sagittate outline to the end view (Fig. 3*c*.) of the carapace, whilst the dorsal view (Fig. 3*b*.) is lanceolata. The ends are rather obliquely, and unequally rounded.

Having much of the appearance of an oblong wedge, this species may be conveniently termed *M. cuneiformis*. The surface does not show any marking.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

10. Metacypris simplex, sp. nov. Pl. XV. Figs. 9 *a*, *b*, *c*.

Length ·4, height ·2, thickness ·2 mm.

Suboblong, but broader (higher) at the anterior third than behind, both ends truncate; the front slightly oblique, and the hinder end gently rounded. The valves are convex; edge view, acute oval; end view, broadly cordate (reversed).

This is smaller, less truly oblong, and more uniformly convex than *M. cuneiformis*, and has to be regarded as a distinct species. The surface is faintly reticulate.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

The known species of *Metacypris* are:—

M. glutea (Egger.). Neues Jahrb. etc. 1858, p. 408, pl. i. fig. 6.
M. strangulata,[1] Jones, Q. J. G. S. vol. xvi. 1866, p. 187, fig. 73.
M. cordata, Brady and Robertson, Ann. Mag. Nat. Hist. ser. 4, vol. vi. 1870, p. 20, pl. vi. figs. 1—9; and Trans. R. Dublin Soc. n.s. vol. iv. 1889, p. 123, pl. xiv. figs. 3—12.
M. Forbesii, Jones, and var. *verrucosa*, Jones, Q. J. G. S. vol. xli. 1885, p. 345, pl. viii. figs. 11—13.
M. Bradyi, Jones, Geol. Mag. 1886, p, 146, Pl. IV. Fig. 2.
M. Whitei, Jones, *loc. cit.* Fig. 3.
M. Fittoni (Mantell), Jones in Prestwich's "Geology," vol. ii. 1888, p. 263, fig. 137*a*; and Geol. Mag. 1888, p. 539.

VI. Cythere, Müller, 1785.

11. Cythere monticula, sp. nov. Pl. XV. Figs. 13*a*, *b*.

Length ·6, height ·35, thickness ·6 mm.

Looking for published species showing definite alliance in form to this specimen, *Limnicythere*, a brackish genus presents itself; but there is no real ground for regarding relationship to exist. *Cythere*

---

[1] *Cypris conculeata*, Jones, Q. J. G. S., vol. xvi. 1866, p. 266, fig. 3, is not a *Metacypris* for certain.

Cluthæ, Brady, Crosskey, and Robertson,[1] which presents variable aspects, with its irregular mammillated surface and subquadrate carapace, is decidedly a nearer ally.

In our specimen the valves are broad (high) in front, narrow and subtruncate behind, the dorsal and ventral borders sloping backwards, and the ventral region bears a definitely sharp ridge (not broad and rounded as in *C. Cluthæ*) for two-thirds of its length. There is also a central tubercle on the valve, with a swelling in front and behind it.

Differing in marked features from the other species, this may be designated *Cythere monticula.*

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

VII. CYTHERIDEA, Bosquet.

12. CYTHERIDEA TRUNCATA, sp. nov. Pl. XV. Figs. 4*a*, *b*.

Length ·7, height ·5, thickness ·3 mm.

There is no evidence of the Cypridean hook in this form, though it has some resemblance to a possibly truncate form of *Cypridea punctata*[2] (Forbes); but I prefer to associate it with *Cytheridea.* Its subtrigonal shape, with truncate front, and oblique posterior end, are characteristics. Its edge view is narrow-oval.

On the surface is visible a shallow pitting, looking almost like a reticulation.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

13. CYTHERIDEA TENUIS, sp. nov. Pl. XV. Figs. 7*a*, *b*.

Length ·6, height ·25, thickness ·2 mm.

This is another form probably belonging to *Cytheridea.* The cast (like Fig. 4) has not retained (if it ever had) any evidence of the Cypridean beak-like process and its accompanying notch. It has a long subtriangularly ovate shape, like that of many different kinds of Ostracodes. The front is well rounded; the posterior rounded, but narrow; the ventral border is straight; the dorsal elliptical, and most convex at the anterior hinge, as in many of the *Cytheridæ.* The surface shows some slight tuberculation.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

VIII. CYTHERIDEIS, Jones, 1857; and Brady and Norman, 1889.

14. CYTHERIDEIS ÆQUALIS, sp. nov. Pl. XV. Figs. 11*a*, *b*.

Length ·6, height ·25, thickness ·4 mm.

It is difficult (if not impossible) to place this form among freshwater and brackish Ostracoda. The *Cypridopsis villosa* (Jurine), as defined by Brady, has a narrow and curved carapace, but more arched on the back and thicker in the middle than Fig. 11. The genus *Cytherideis,* of which only marine forms are known, offers a more convenient asylum for this narrow, curved carapace with the ends equally rounded, but with an anterior compression of the valves

---

[1] Monogr. Post-Tert. Entom., Pal. Soc., and more lately treated of by Brady and Norman in Trans. R. Dublin Soc., n.s., vol. iv. 1889, p. 145, pl. xiv. figs. 25–27; and pl. xviii. figs. 25 and 26.

[2] Quart Journ. Geol. Soc. vol. xli. 1885, p. 357, pl. viii. figs. 1–8.

(Fig. 11*a*.), giving a sharp-lanceolate edge view (Fig. 11*b*.). In this case *Cytherideis gracilis* (Reuss) and *C. botellina* (Jones) are among its nearest allies; but neither of them matches it exactly. I propose to name it *C. æqualis*.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

15. CYTHERIDEIS IMPRESSA, sp. nov. Pl. XV. Figs. 12*a*, *b*.

Length ·6, height ·25, thickness ·17 mm.

A narrow and curved carapace of nearly equal thickness throughout except where constricted with a broad and shallow impression in the middle of the ventral region.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

EXPLANATION OF PLATE XV.

All the figures magnified 20 diameters.

FIG. 1. *Metacypris consobrina*, sp. nov.; *a*, carapace, left valve shown; *b*, edge view; *c*, end view.
,, 2. ——— *subcordata*, sp. nov.; *a*, left valve shown; *b*, edge view; *c*, end view.
,, 3. ——— *cuneiformis*, sp. nov.; *a*, right valve shown; *b*, edge view; *c*, end view.
,, 4. *Cytheridea truncata*, sp. nov.; *a*, left valve shown; *b*, ventral edge.
,, 5. *Cypridea tuberculata* (Sow.), var. *Wyomingensis*, nov.; *a*, right valve shown; *b*, ventral edge.
,, 6. The same; *a*, left valve shown; *b*, ventral edge.
,, 7. *Cytheridea tenuis*, sp. nov.; *a*, left valve shown; *b*, edge view.
,, 8. *Potamocypris affinis*, sp. nov.; *a*, right valve shown; *b*, ventral edge.
,, 9. *Metacypris simplex*, sp. nov.; *a*, right valve shown; *b*, edge view; *c*, end view.
,, 10. *Potamocypris unisulcata*, Jones; *a*, left valve; *b*, edge view.
,, 11. *Cytherideis æqualis*, sp. nov.; *a*, carapace, left valve shown; *b*, edge view.
,, 12. ——— *impressa*, sp. nov.; *a*, right valve shown; *b*, edge view.
,, 13. *Cythere monticula*, sp. nov.; *a*, left valve shown; *b*, ventral view.
,, 14. *Candona subreniformis*, sp. nov.; *a*, right valve; *b*, edge view.
,, 15. *Cypris Purbeckensis*, E. Forbes; *a*, carapace, right valve shown; *b*, edge view.
,, 16. *Candona subovata*, sp. nov.; *a*, right valve shown; *b*, edge view.

II.—THE EVOLUTION OF THE AMERICAN TAPIR.

By CHARLES EARLE, B.Sc.,
of the American Museum of Natural History, New York.

THE genus *Tapirus* of all the recent Ungulata, is the most discontinuous in its distribution over the Earth's surface. Wallace, in his great work on the "Geographical distribution of Animals," in referring to extinct Tapirs, remarks: "the singular distribution of the living species is thus explained, since we see that they are an old world group, which only entered the American continent at a comparatively recent epoch." He reaches this conclusion by the fact that at the time his work was written (1876) the only known remains of the Tapiridæ in America were from the Post-Pliocene deposits.

Our knowledge has been greatly increased as regards fossil tapirs in America within the past few years, and the discovery of the genus *Protapirus* of Filhol, by the expedition sent out by the American Museum of Natural History in the Lower Miocene of Western Dakota, has added another very important link in the phylogeny of the American Tapir. This discovery places the origin of the Tapir in America on a level stratigraphically with one of the species of *Protapirus* in Europe. We shall therefore expect that further discovery will perhaps prove the existence of the true Tapir in America, earlier than the Oreodon beds of the White River Miocene.

Many authors have attempted to solve the problem of the origin of the Tapir in America. Professor Marsh[1] in 1877 held the view that the genus called by him *Helaletes*, was the ancestor of the true Tapir. Professor Scott[2] followed Marsh in deriving the Tapir from *Helaletes* (*Desmatotherium*).

Prof. Cope[3] was the first investigator to recognize that in the Wasatch and overlying Wind River beds, two types of Tapiroid superior molars were already then evolved. In the one, *Systemodon*, both external lobes are conical, and in the other *Heptodon*, the postero-external lobe is concave. This point is of great importance as shown by Prof. Osborn in tracing the ancestral history of these Perissodactyla. Prof. Osborn[4] in the "Uinta Mammalia" removed *Helaletes* from the line leading to the true Tapirs, and placed *Systemodon* as *the stem* form of the latter. Later, Prof. Osborn[5] explained more fully his reasons for removing *Helaletes* from the Tapir line, and in this paper characterized the form of the superior molars in the three Tapiroid phyla of the Eocene.

The recent discovery of *Protapirus* in America shows that this genus was represented by two species, one derived from a division of the White River Miocene (Oreodon beds), lower than the other (Protoceras beds). If we carefully compare the species of *Protapirus* figured by M. Filhol[6] with those found in America[7] we will find a remarkably close resemblance in the characters of their teeth, and in fact it is quite difficult to separate the *Protapirus obliquidens* from the *P. Douvillei* of St. Gérand-le-Puy.

In studying the early ancestors of the Tapirs in the Eocene of America, we observe certain differences in their foot-structure, and in the simplicity of the premolar teeth. These characters differentiate the early Tapirs from the later or true Tapirs. We notice first, that the earliest known Tapiroid, namely *Systemodon*, has the premolars less complex in structure than the true molars, and only the third and fourth superior premolars in this genus have internal cones. The upper true molars consist of two conical external lobes, which are of equal length transversely. This is a very important character in diagnosing the early Tapiridæ from the Rhinocerotidæ.

---

[1] O. C. Marsh, Introduction and succession of Vertebrate Life in America, delivered before the American Association at Nashville, 1877.

[2] W. B. Scott, On *Desmatotherium* and *Dilophodon*, two new Eocene Lophiodonts, Bull. Princeton College, 1883, p. 46.

[3] E. D. Cope, The *Perissodactyla*, American Naturalist, 1888, p. 990.

[4] W. B. Scott and H. F. Osborn, The Mammalia of the Uinta Formation, Trans. Amer. Phil. Soc. 1889, p. 523.

[5] H. F. Osborn and J. L. Wortman, Fossil Mammals of the Wasatch and Wind River Beds, Bull. Amer. Mus. Nat. Hist. 1892, p. 124.

[6] H. Filhol, Reserches sur les Phosphorites du Quercy, 1877, p. 351.

[7] *Ibid.*, Observations sur le memoire de M. Cope, etc., Ann. Sci. Geol. vol. xvii. art. 2.

In the latter group, the postero-external cone of the upper molars in later forms has a tendency to lengthen and become concave. The upper molars of *Systemodon* are provided with two complete transverse crests and there is a large antero-external cingular cusp. The lower series of teeth in *Systemodon* exhibit an interval or diastema behind the first premolar. This tooth is placed, however, close to the canine, which is considered to be a character typical of the early Tapirs. The fourth inferior premolar in *Systemodon* is simpler in structure than a true molar; it has, however, two anterior cusps and a low heel. The latter is unprovided with a postero-internal cusp.

In the further evolution of the Tapir this is the tooth which becomes molariform in structure. The last lower molar of *Systemodon*, like all the Eocene Tapirs, has a large third lobe. This character, and the less complexity of the premolars, sharply divides the Lower Eocene Tapirs in America from their Miocene descendants. Wortman and Earle[1] have lately shown it is probable that *Systemodon* had a rudiment of the fifth metatarsal on the hind foot. In the contemporary genus *Hyracotherium* of the Wasatch, this metapodial had disappeared. As far as vertebrate palæontology has progressed in regard to the fauna of the Wasatch Eocene, we may conclude that the genus *Systemodon* may be considered as standing in ancestral relations to both the Tapiridæ and Rhinocerotidæ.

In the Wind River beds of America we meet with the genus *Heptodon*. This form has a superior molar indicating that it is off the line leading to the true Tapirs; the postero-external cusp has become concave, and reminds one of that occurring in the genus *Hyrachyus*. *Heptodon* is considered by Prof. Osborn to be the ancestor of *Helaletes* of the Middle Eocene. The *Heptodon-Helaletes-Colodon* line was a phylum of the Perissodactyla, contemporary with the *Systemodon-Isectolophus-Protapirus* line, but leading to a form (*Colodon*) more specialized than *Protapirus*. *Colodon* has lost the outer incisor of the lower jaw, and the fifth digit of the manus is much smaller than in *Protapirus*.

There has as yet been no representative of the true Tapir line discovered in the Wind River beds of America. In the Bridger we find the genus *Isectolophus*, which should probably be placed in the line leading to the Tapir. The dentition of this genus is not yet fully known, especially the species from the Uinta. In *Isectolophus latidens* the third superior premolar has two internal cones, but the fourth tooth of this series is still simple in structure, like that of *Systemodon*. The true molars closely resemble those of the latter genus. The structure of the last inferior premolar of *I. latidens* is not known, but it was probably nearly molariform. The lower true molars show little advance over those of *Systemodon*; the last lower molar still retains the large third lobe.

Referring to the Uinta Tapir, namely, *Isectolophus annectens*, we notice in this species that the external face of the upper molars is more oblique than in the Wasatch Tapir, the last lower premolar is nearly transformed into the complexity of a molar. The last inferior true molar in this species is like that of the *I. latidens* in having a large third lobe. Until the structure of the upper premolars is known in the *I. annectens*, we cannot say with certainty whether this form led to the true Tapir.

---

[1] J. L. Wortman and Charles Earle, Ancestors of the Tapir from the Lower Miocene of Dakota, Bull. Amer. Mus. Nat. Hist. July, 1893.

The structure of the manus in *Isectolophus annectens* is of great interest, and illustrates the small change which the foot of the Tapir has undergone since the Upper Eocene. This species has four well developed toes on the anterior foot, and the fifth toe is larger in comparison with the size of the third than in the recent Tapir. The upper and middle element of the carpus, the lunar bone, has two nearly equal distal articular faces; this character of the lunar showing that the four digits of the manus are more nearly equal in size than in modern types.

In the evolution of the foot structure of the odd-toed Ungulates or Perissodactyles with the reduction of the toes, there has been a concomitant displacement of the carpal and tarsal elements. For example, one of the most primitive of the Ungulates, the genus *Phenacodus*, has these elements arranged one above the other, the serial order as it is called, and co-ordinated with this structure is the presence of five well-developed digits on each foot. In all the known species of the Tapir, however, there has taken place a high degree of displacement. We have observed[1] considerable difference in the foot structure of two species of recent Tapir, but all the modern forms are more specialized in this respect than their Eocene ancestors. The most noticeable change in the relations of the bones of the carpus in the evolution of the Tapir series, is the change in extent of articulation between the lunar and magnum, and the lunar and unciform. In the more specialized forms the anterior articulation between the lunar and magnum is shut off entirely; these relations are connected with the reduced size of the fifth toe, and as a result the lunar comes to have a large articulation with the external and inferior bone of the carpus, the unciform. These morphological characters are extremely important in tracing out the phylogeny of the Perissodactyla.

There is a break in the ancestral history of the Tapir in America between the Upper Eocene and the middle layer of the White River Miocene; in Europe this record is more complete than in America. The earliest known species of *Protapirus* from America is the *P. simplex* from the middle layer, or Oreodon beds of the White River formation. The only known remains of this species are the superior premolars and fragments of the lower jaw. It is of surprising interest to find a Perissodactyle so high up as the White River beds, having premolars so simple in structure. In all the other Perissodactyla of this epoch the premolars have become as complex as the true molars. In *P. simplex* the internal lobes of the superior premolars are absolutely simple in structure, and consist of only a single internal cone. This species is nearly as large as its successor in the upper layer of the Lower Miocene.

---

[1] Charles Earle, Some points in the Comparative Osteology of the Tapir, Science, March, 1893.

The best known American species of *Protapirus* is the *P. obliquidens* from the Protoceras beds of the Lower Miocene. This species is represented in the American Museum Collection by the upper and lower dentition, and a finely-preserved manus. The comparison of the upper premolars of *P. simplex* with those of *P. obliquidens* reveals the fact that the internal cones of these teeth in the latter species are in a transition stage of development, and are intermediate in structure between those of the earliest species of *Protapirus*, viz. *P. simplex* and the recent Tapir. In the genus Tapirus the last three superior premolars are truly molariform, and consist of two external cones and two complete transverse crests; the latter being entirely separated internally. Now in *P. obliquidens* the internal cones of these teeth are deeply bilobed at their summits, especially the last two of the series; the anterior crest is well marked, but the posterior less so. It is interesting, from a phylogenetic point of view, to notice that the anterior crest of the premolars in the Tapiridæ is the first to be developed, and later the posterior appears by an elongation transversely of the posterior intermediate tubercle.

The characters of the upper true molars of *Protapirus obliquidens* are nearly the same as those of Tapirus; their peculiarity is the obliquity of the external lobes and also of the posterior crest. The lower jaw of the American Lower Miocene Tapir is nearly as large as that of the Brazilian Tapir. The inferior premolars, like the upper, are simpler in structure than those of the recent Tapir; this applies especially to the posterior crest, which is undeveloped. We find that the last lower true molar has lost the large third lobe so characteristic of the Eocene Tapirs of America.

The foot structure of the American species of *Protapirus* shows that it is nearly identical with the recent form. In contrast with the Brazilian Tapir we notice the greater size of the fifth toe in comparison with the middle digit. The elements of the carpus are much displaced in *Protapirus*, and only differ from the recent Tapir in their rather more elongated form.

One of the contemporaries of Protapirus in the Lower Miocene of America is the genus *Colodon* (*Mesotapirus*, S. & O.). This Tapiroid resembles *Protapirus* somewhat in the structure of its teeth, but in the lower jaw the external incisor is absent. We can readily distinguish between the true Tapirs and the pseudo-Tapirs of the Lower Miocene by the form of the postero-external lobe of the superior molars, as already described. The structure of the manus of *Colodon* differs considerably from that of *Protapirus*. In the former genus the fifth digit is very small, and there is some enlargement of the middle digit. In fact the structure of the manus in this genus proves that it was tending towards monodactylism; this is also shown from the reduced size of the ulna as compared with the size of the radius. Phylogenetically *Colodon* is now considered to be the outcome in the Miocene of the Bridger (Eocene) genus *Helaletes*.

In *Tapiravus*, Marsh, from the Pliocene the last two premolars are as complex as the molars. Prof. Marsh considers this form closely related to the recent Tapir and standing in ancestral relationship to it.

The distribution of the genus Tapirus in Post-Pliocene times in America appears to have been very general, and remains of Tapirs are recorded from many of the Southern and Western States.

In conclusion, we may summarize the following points in the evolution of the Tapir, and the relationship between the American and European species of *Protapirus*: 1. True Tapirs make their first appearance in America in the Lower or White River Miocene; this formation is higher stratigraphically than that in which *Protapirus* (*P. priscus*) occurs in Europe.

2. The American species, *Protapirus obliquidens*, is in about the same stage in the evolution of its premolars as that of the *P. Douvillei*, from St. Gérand-le-Puy in France.

3. *Protapirus priscus* of the Phosphorites is a much higher developed type than its probable contemporary in America, namely, *Isectolophus annectens*.

4. In contrast with the other Perissodactyla of the White River formation, the premolar teeth of *Protapirus* are simple in structure, and have not assumed the pattern of the true molars as in the recent Tapir.

5. We cannot agree with M. Filhol, that the genus *Protapirus* is the same as the American genus *Hyrachyus*. We believe these genera are entirely distinct.

III.—The Pre-Cambrian Rocks of Wales.[1]

By Henry Hicks, M.D., F.R.S., F.G.S.

In a recent article on the Pre-Cambrian Rocks of the British Isles in the Journal of Geology, vol. i., No. 1, Sir Archibald Geikie makes the following statement: "There cannot, I think, be now any doubt that small tracts of gneiss, quite comparable in lithological character to portions of the Lewisian rocks of the North-West of Scotland, rise to the surface in a few places in England and Wales. In the heart of Anglesey, for example, a tract of such rocks presents some striking external or scenic resemblance to the characteristic types of ground where the oldest gneiss forms the surface in Scotland and the West of Ireland." To those who have followed the controversy which has been going on for nearly thirty years between the chiefs of the British Geological Survey and some geologists who have been working amongst the rocks in Wales, the importance of the above admission will be readily apparent; but as it is possible that some may be unable to realize what such an admission means in showing geological progress in unravelling the history of the older rocks in Wales during the past thirty years, a brief summary of the results obtained may possibly be considered useful. It is now twenty-nine years since it was announced by Mr. Salter (at the meeting of the British Association, 1864) that during researches carried on by him in conjunction with myself at St. Davids, in Pembrokeshire, we had found "that the mass of igneous rock which forms the backbone of the St. Davids peninsula, and which supports, without penetrating them, the shallow water accumulations of the older Cambrian around it," was a "part of the old Pre-Cambrian land," and that "as the purple rocks, sandstones, and slates of the whole Lower Cambrian division are thrown up at high angles, all but vertical on either flank of this mass, which forms the axis of the whole country, there is no difficulty in studying its behaviour in contact with the Cambrians." Moreover, it was stated that "if it were an intrusive trap of later date it would penetrate them here and there, or at least alter them at the point of contact. On the contrary, wherever the boundary can be seen, steatitic and felspathic schists unaltered, and beds of thick conglomerate mark the line and are often very conspicuous. These conglomerates of quartz rock, jasper, felstone, etc., may or may not have been derived from the immediate neighbourhood. They are traceable along the south and north sides of the trap region, and are followed by sandstones of various degrees of coarseness, but indicating by the ripple-mark, as well as the coarse material, that they were accumulated in shallow water; and as we know that pebbles often as large as swans' eggs, are not carried far out to sea, but mark either a submarine shoal or a coast-line, we are compelled to assign them to a source near at hand."[1] The above remarks (Brit. Assoc. Report and Geol. Mag. 1864) were written as already stated twenty-nine years ago, and the evidence since obtained has confirmed in a marked degree the main conclusions we then arrived at. The great mass referred to was then, and still remains, marked on the map of the Geological Survey as syenite and felstone, chiefly of Lower Silurian age. The view put forward by Mr. Salter and myself that it was of Pre-Cambrian age was, as is well-known, most strongly opposed by the chiefs of the Geological Survey, and up to a very recent period they have persistently denied that there were any Pre-Cambrian rocks in Wales. Further researches in other districts in Pembrokeshire and in North Wales enabled me to announce that there was evidence to show that several other great masses of igneous rocks shown on the maps of the Geological Survey as intrusive in Cambrian and Lower Silurian strata, were in reality portions of a Pre-Cambrian land which had been forced up by great earth movements and afterwards exposed to view by denuding agencies. This mass at St. Davids and others of a like nature in Anglesey and Carnarvonshire had been credited by the Geological Surveyors with producing marked metamorphic changes in the rocks which surrounded them, so that large areas in their immediate neighbourhood were coloured as metamorphosed Cambrian and Silurian strata. These so-called metamorphosed rocks, as will be explained further on, I was able subsequently to show to be mainly volcanic rocks of Pre-Cambrian age. The igneous rocks in Wales, which are now admitted to be of Pre-Cambrian age by the majority of the geologists who have examined them, are marked on the Geological Survey maps either as syenite, granite, felstone or felspathic porphyry. These masses, subsequent to their consolidation, have been freely traversed by dykes of acid and basic igneous rocks, and the signs of alteration which are occasionally seen are due to contact with these dykes. Some of the dykes are undoubtedly of Pre-Cambrian age, and they show clear indications of having suffered from the movements which affected the rocks in Pre-Cambrian times; others are of more recent date, and traverse both the Pre-Cambrian and the overlying series. Igneous rocks of somewhat similar character to some of the masses now classed as of Pre-Cambrian age may be recognized here and there as having been intruded into Cambrian and Lower Silurian strata; but these do not show evidence of having been crushed or foliated to anything like so marked a degree as the similar rocks of Pre-Cambrian age. To the granitoid rocks (massive and gneissose), in the year 1877, I gave the name "Dimetian," and I classed them as the oldest of the Pre-Cambrian rocks in Wales. They are in fact the rocks which Sir Archibald Geikie now says are "quite comparable in lithological character to portions of the Lewisian rocks of the North-West of Scotland." It is important to note that in our earlier papers we classed these masses, as we do now, as of igneous origin, maintaining that they were of Pre-Cambrian age, and not intrusive in the Cambrian and Lower Silurian strata; but unfortunately the extravagant views subsequently in vogue in regard to questions of metamorphism led us, like others, for a time to believe that it was possible that even some of these massive crystalline rocks might originally have been sedimentary strata. When the microscope, however, was more freely used in their examination, it became apparent that they could not at any time have been sediments, and Professor Bonney, Mr. T. Davies, Dr. Callaway, Mr. Teall, and others have now clearly demonstrated that they are in the main igneous bosses, some still retaining their massive character though showing indications of having been much crushed, others assuming a schistose or gneissose appearance as the result of pressure and metamorphism. I have readily admitted in previous papers that since these rocks have been proved to be of igneous origin they cannot have the same value for purposes of classification as when they were supposed to be metamorphosed sediments; but on the other hand it is clear that they are older than the quartzites and other sediments of Pre-Cambrian age which frequently contain fragments derived from them. At the meeting of the British Association in 1878, I announced for the first time that I had obtained evidence to show "that the so-called intrusive granites in Anglesey and the whole of the area marked as altered Cambrian in that island" were of Pre-Cambrian age. I classed the rocks there under three names as follows:—

---

[1] Paper communicated to the Geological Congress, Chicago, August, 1893.

---

[1] The basal Cambrian conglomerates at St. Davids, which in places are over a hundred feet in thickness, often contain very large pebbles. This day (Aug. 17th) I measured two well-rounded blocks at the base of the conglomerate where it rests on the upturned edges of the Pebidian strata at Whitesand Bay, which gave the following dimensions:—

Quartzite pebble with a slightly purplish tinge, 18 inches in length, 12 in width, and 9 in thickness. Quite near to the above was a well-rolled block of vein quartz, 17 inches in length, 16 in width, and 11 in thickness. On the same face dozens of pebbles 6 to 8 inches across were also visible; and amongst them were numerous somewhat smaller pebbles of slaty and compact volcanic ash, porcellanite, schistose felstone, etc., which had undoubtedly been derived from the underlying Pebidian rocks. The enormous quantity of quartzite, and the frequent presence of fragments of quartzose schists, in the conglomerate prove clearly that there must be a hidden ridge of such rocks (Arvonian) near at hand. The quartz-grains and bits of felspar which formed these quartzites and schists were primarily derived fram Granitoid rocks (Dimetian), such as are now seen at St. Davids, and on the coast at Poulthikey. In addition, therefore, to showing the marked unconformity on the Pebidian, these conglomerates yield indisputable proof of the exposure of three Pre-Cambrian groups in the St. Davids area when they were deposited. No amount of ingenious argument can alter these facts, and the evidence is perfectly clear to those who desire to reach it.

DIMETIAN, to include the granitoid rocks and gneiss.

ARVONIAN, the schistose and compact quartz rocks and some felsites and porphyries.

PEBIDIAN, green and purple agglomerates and breccias, green chloritic schists, with massive greenstone bands, talcose schists, etc.

In the previous year, 1877, Prof. Hughes and I, in separate papers, had pointed out that there were masses of granitoid rocks and of quartz felsites in Carnarvonshire, which had every appearance of being older than any of the Cambrian rocks. It was stated that they resembled in a marked degree some of the Pre-Cambrian rocks of Pembrokeshire, and that as in that area they were flanked by unaltered Cambrian sediments. The volcanic series in Pembrokeshire, in Carnarvonshire, and in Anglesey we placed as the highest group, and we showed that the overlying Cambrian conglomerates reposed transgressively on, and contained large pebbles derived from, beds belonging to that series. We have since shown that the Cambrian conglomerates in reality are made up of fragments derived by denudation from the three series referred to, and that an important interval must have elapsed between the upturning of the beds, even of the latest of the Pre-Cambrian series, and the deposition upon them of the basal Cambrian conglomerates.

In the paper already referred to Sir Archibald Geikie says that the schists, quartzites and limestones in Anglesey present a close resemblance to the Dalradian series of Scotland and Ireland "and that the coarse gneiss" may be compared, in general character, with parts of the Lewisian rocks, so that we seem to have here, as in Ireland, two groups of schistose rocks, and both of these much older than the unaltered Cambrian strata which lie above them. I have already stated that the oldest group, "coarse gneiss," above referred to was mapped by the Geological Surveyors as granite intrusive in Cambrian and Silurian strata, and that no suspicion that it was of Pre-Cambrian age was entertained until the year 1878, when I pointed out that it resembled in a marked degree the "Dimetian" of St. Davids, and stated that I had obtained evidence to show that it was not intrusive in the surrounding rocks. At first I associated the "quartzose rocks" with the "Dimetian," but afterwards placed them in a newer group "Arvonian," and in this group I included the "schistose and compact quartz rocks, breccias, halleflintas, and quartz-felsites" of Holyhead Mountain, Bodafon Mountain, and Ty Croes, in Anglesey. This group, therefore, was made to include the majority of the rocks now stated by Sir Archibald Geikie to have a close resemblance to the "Dalradian series" of Scotland, and the term "Arvonian" should therefore be retained for them. The next group in Anglesey, the "Pebidian," is mainly a volcanic series, but it contains also many beds of clastic origin. Sir Archibald Geikie says that he regards the so-called Pebidian "as merely marking the duration of a volcanic period in early Cambrian time."

Other British geologists, including Prof. Hughes, Prof. Bonney, Dr. Callaway and Mr. Blake, who have examined these rocks at St. Davids and in Anglesey, are satisfied that they are of Pre-Cambrian age and that I correctly assigned them to that horizon when I first described and classed them as a group under the name "Pebidian." As the so-called "Dalradian series" has been referred to for purposes of comparison with some of the Anglesey rocks, it may be well to state what the term "Dalradian" was at first intended to include. In his address to the Geological Society in 1891, when the name was first used, Sir A. Geikie said, "I have myself no doubt that the rocks are far more ancient than any that could be classed as Lower Silurian, though it is of course conceivable that portions of even Lower Silurian strata have been caught in their plications and have undergone metamorphism. If they are claimed as Pre-Cambrian, I am not aware of any better proof that can be furnished against than in favour of such a claim. They may possibly include equivalents of the Torridon Sandstone as well as the Durness groups, and even portions of the upthrust Archæan platform." He further states that "Such a name need not be a permanent addition to geological terminology, but it might, at least for some time, be usefully adopted as a convenient epithet until the true stratigraphical position of the rock is definitely ascertained."

Now that Sir A. Geikie has satisfied himself as to the close resemblance of the Pre-Cambrian rocks in Anglesey with the so-called "Dalradian" of Scotland, the time appears to me to have arrived when that term should be dropped or not further used when reference is made to the crystalline schists of the Central Highlands, which I classed in the year 1880 (eleven years before the term Dalradian was employed by Sir A. Geikie) as a Pre-Cambrian group under the far better and more distinctive term "Grampian." The Pre-Cambrian rocks of Wales, therefore, according to the most recent views, resolve themselves into three well marked groups, and the chronological order is that in which I placed them in the years 1877 and 1878. Some rocks, owing to our having since obtained more satisfactory evidence of their position, have been removed from one group and placed in another; and in some few instances have been removed from the groups. Such changes, which necessarily must occur with improved knowledge, do not in any way warrant the adoption of new names for groups which still show the main distinctive characters under which they were first described.

The rocks in Wales classed as Dimetian, Arvonian, and Pebidian may or may not be equivalents of the rocks in Scotland called by the names Lewisian, Grampian, and Torridonian; but at present it is far safer and certainly fairer that the groups should retain the names given to them in the country where their positions were first recognized.

IV.—THE GEOLOGICAL DEVELOPMENT, DESCENT AND DISTRIBUTION OF THE MAMMALIA.[1]

By Prof. KARL A. VON ZITTEL, Ph.D., For. Memb. Geol. Soc. Lond.
Professor of Palæontology in the University of Munich.

IN a spirited treatise on the 'Origin of our Animal World' Prof. L. Rütimeyer,[2] in the year 1867, described the geological development and distribution of the mammalia, and the relationship of the different faunas of the past with each other and with that now existing. Although, since the appearance of that masterly sketch the palæontological material has been, at least, doubled through new discoveries in Europe and more especially in North and South America, this unexpected increase has in most instances only served as a confirmation of the views which Rütimeyer advanced on more limited experience. At present, Africa forms the only great gap in our knowledge of the fossil mammalia; all the remaining parts of the world can show materials more or less abundantly, from which the course followed by the mammalia in their geological development can be traced with approximate certainty.

MESOZOIC ERA.

The oldest remains of mammals come from the Triassic rocks. Detached teeth of *Microlestes* and *Triglyphus* from the Rhætic beds of Würtemberg and England, a skull of *Tritylodon* and skeletal fragments of *Theriodesmus* from the Karroo beds of South Africa, prove the wide distribution of the unfortunately still very imperfectly known Allotheria at the beginning of the Mesozoic period. If it is at present not yet possible to indicate the settled position of these small plant-eating or omnivorous animals in the zoological system, it yet remains certain that they can only be compared with the lowest organized of existing mammals, the Monotremata and Marsupialia; and neither in their dentition nor in the form of the skull do they show relations to Reptilia or Amphibia. Quite another group of primitive mammalia of small dimensions is indicated by two small lower jaws from the upper Trias of North Carolina. The genera *Dromatherium* and *Microconodon* remind one of Insectivora and Marsupialia, but they differ from both in the highly primitive triconodont molars, in which the crown is not sharply separated from the root, which is simple, or only incompletely-divided by a lateral furrow. The slender styliform incisors and powerful canines show further that the Triassic Protodonts of America possessed a not less differentiated dentition than the Tritylodontidæ from Europe and South Africa.

---

[1] Translated, with the permission of the author, by Dr. G. J. Hinde, V.P.G.S., etc., from the German, Aus den Sitzungsberichten der mathematisch-physikalischen Classe der k. bayer. Akad. d. Wiss. 1893. Bd. xxiii. Heft. II. pp. 137–198. The present treatise forms the concluding chapter of the 4th volume of the author's Handbook of Palæontology, Munich, R. Oldenbourg, 1893.

[2] Rütimeyer L. Ueber die Herkunft unserer Thierwelt. Eine zoogeographische Skizze. Basel. 1867.

In the Jurassic period both the Allotheria and the insect-eating Marsupials increased and became further developed. The Great Oolite of Stonesfield and the Purbeck 'Dirt-bed' are still the only localities in Europe in which they have been found, but besides these the Upper Jurassic "Atlantosaurus Beds" in Wyoming and Colorado have yielded a wealth of new forms, which, however, like their European contemporaries, are mostly represented by jaws and small detached teeth, and very seldom by other bones of the skeleton. The Jurassic Allotheria are divided into two families, as yet very insufficiently characterized; of these, one (Bolodontidæ) is only represented by upper jaws; the other (Plagiaulacidæ) principally by lower jaws. In the structure of the molars these last agree with the Triassic *Microlestes*, but the lower premolars possess the form of cutting, laterally-grooved, blades, like those now only present in the grass-eating Kangaroo-rats (Hypsiprymnidæ). The rodent-like incisors also admit of comparison with those of *Hypsiprymnus* and other Diprotodont Marsupials. The circumstance is of interest that up to the present only two genera (*Plagiaulax* and *Bolodon*) are known from the Purbeck beds of England, and that North America possesses two nearly related representative forms in *Ctenacodon* and *Allodon*. Of the minute *Stereognathus* from the Great Oolite of Stonesfield with crescent-shaped tubercles on the molars, only a single jaw is known.

Besides the Allotheria, there are in the Jurassic strata of Europe and North America a considerable number of genera having molars with three pointed cusps, conical canines, and styliform or spatulate incisors, which seldom exceeded a rat in size and mainly lived on insects. The European forms were all placed by Owen with the Polyprotodont Marsupials and compared with the living *Myrmecobius*, but it is only in certain genera in which the dentition and form of the jaw exhibit such plainly marked marsupial characters, that their position can be certainly determined; in many instances a mingling of the peculiarities of Marsupials and Insectivora renders a decision impossible. Marsh solved the question in a radical manner by placing the Mesozoic mammals with pointed teeth in an independent order, *Pantotheria*; Osborn recognises in them the ancestors of the Polyprotodont Marsupials and of the Insectivora. Unfortunately our knowledge of these ancient mammals depends at present entirely on jaws, isolated teeth, vertebræ, and some rare bones of the extremities. No pelvis with the characteristic marsupial bones has, as yet, been discovered. As in the Allotheria, so also in the Jurassic Polyprotodonts there is an astonishing similarity, and in some instances, even complete resemblance between the European and American genera. In the following list the corresponding genera on both continents are placed opposite each other, and those from the English Great Oolite are indicated by (G. O.) and those from the Purbeck by (P.).

ENGLAND.	NORTH AMERICA.
Amphilestes (G. O.)	*Priacodon.*
Triconodon (P.)	*Triconodon.*
Phascolotherium (G. O.)	
Spalacotherium (P.)	*Tinodon.*
	Dicrocynodon.
	Docodon.
	Ennacodon.
Amphitherium (G. O.)	
Peramus (P.)	
Amblotherium (P.)	*Paurodon.*
Achyrodon.	*Laodon.*
	Dryolestes.
	Asthenodon.
Curtodon (P.)	

The Jurassic Mammalia have been formerly supposed to bear an Australian facies; but a comparison of the existing Marsupials of Australia with the Jurassic Allotheria and Pantotheria shows, however, only very limited points of connection between them. The Mesozoic forms exhibit a much more uniform character than their more strongly differentiated Australian relations, and the main agreement of the two faunas consists in the absence of placental genera.

No traces of Mammalia were known from the Cretaceous formation until the year 1882. Now, isolated teeth of the genus *Plagiaulax*, already known in the Jurassic, have been found in the English Wealden, and from the so-called Laramie-beds of Western America a notable number of teeth and fragments of jaws have been described by Marsh. The hopes which had been earlier entertained of the discovery of Cretaceous Mammalia, have not been altogether fulfilled, for those which have been found up to the present indicate that the Jurassic forms had passed through but slight changes in the Cretaceous Epoch, and that Allotheria, Pantotheria, and perhaps a Tillodont-genus (*Stagodon*) still constituted the primitive stock of the Mammalian fauna of this period. The expected precursors of the Ungulates, Carnivora, Rodents, and other placental orders have not been discovered. The numerous genera founded by Marsh on detached teeth have been greatly reduced by Osborn; the, in some measure, well-grounded forms, such as *Meniscoëssus, Cimolomys, Allacodon* and *Oracodon* are closely connected with the Jurassic *Allotheria*, or, such as *Dryolestes* and *Pediomys*, with the Pantotheria. Some small jaws and teeth referred to *Didelphops, Cimolestes, Telacodon* and *Batodon* appear to be genuine Marsupials (Didelphyidæ). Thus the diminutive forms of the Cretaceous Mammalian fauna appear to be an extension of the Jurassic and not the forerunners from which the infinitely richer and more varied Tertiary fauna can be traced.

With the beginning of the Tertiary era the sources of our knowledge of fossil Mammalia are much more abundant than in the Mesozoic period.

I. Lowest Eocene.

Already in the intercalated fresh-water beds in the neighbourhood of Rheims, belonging to the Lowest Eocene, a very remarkable fauna has been discovered by Lemoine.[1] Only the genera *Neoplagiaulax* and *Liotomus* are linked to the Allotheria of the Upper Chalk, the remaining constituents of the "Fauna of Cernays" belong to the Placental mammalia. Small Insectivora (*Adapisorex*) and Carnivora (*Creodontia*) of a very primitive type (*Procynictis, Dissacus, Hyænodictis, Tricuspiodon, Arctocyon, Conaspidotherium, Arctocyonides, Plesiesthonyx, Protoproviverra*), which, indeed, with the exception of the prominently large *Arctocyon*, are only represented by very scanty remains; further, some five-toed ungulates of the order Condylarthra (*Pleuraspidotherium, Orthaspidotherium*), and two doubtful Lemurs (*Plesiadapis* and *Protoadapis*) compose this oldest Tertiary assemblage of animals in Europe.

A remarkably similar contemporaneous fauna comes from the "Puerco-beds" of New Mexico. According to Cope[2] the vertebrate fauna of Puerco consists of twelve species of reptiles, one of birds, and ninety-three of mammals. Of these last, no fewer than 45 belong to the Creodontia (*Mioclænus, Tricentes, Chriacus, Protochriacus, Oxyclænus, Pentacodon, Goniacodon, Sarcothraustes, Deltatherium, Triisodon, Dissacus, Didymictis,* and others), 24 to the Condylarthra (*Haploconus, Anisonchus, Zetodon, Hemithlæus, Periptychus, Ectoconus, Protogonia*), 2 to the Amblypoda (*Pantolambda*), 5 to the Lemurs (*Mixodectes, Indrodon*), 7 to the Tillodontia (*Psittacotherium, Hemiganus, Conoryctes, Onychodectes*), and 11 to the Allotheria, amongst which the genus *Polymastodon*, is much larger than the associated genera *Neoplagiaulax, Ptilodus* and *Chirox.* The more varied composition of the American fauna corresponds with its greater abundance, but the only new order not present in the European fauna is the Tillodontia, and this is probably already represented in the Upper Chalk by the genus *Stagodon* (Thlæodon). If we review, as a whole, the mammals from Rheims and Puerco, we find, together with certain Allotheria continued from the Chalk (which here reach their maximum and then disappear finally), and together with the puzzling Tillodontia, which die out in the Eocene, four different orders of Placental mammals (Creodontia, Condylarthra, Amblypoda, Pachylemuria). The typical representatives of these four orders in the Newer Eocene, where they first attain their complete development, stand, in external appearance and in their general organization, far from each other; the forms from the faunas of Cernays and Puerco, on the other hand, are connected together so closely by a number of features in common, that in many instances it is difficult to decide to which order they may belong. They all possess five-toed plantigrade extremities, of which the terminal phalanges are provided neither with genuine hoofs nor with real claws, but with a something intermediate between both; in all, the bones of the fore-arm and foot remain separate; the humerus is nearly always penetrated by an entepicondylar foramen; the femur has a third trochanter and a *centrale* was present in the carpus of most, probably of all the forms. The skulls, generally, have a depressed, longitudinally-extended form; strongly developed facial-bones, a diminutive brain-case, smooth cerebral hemispheres, which do not project over the cerebellum. There is, further, no very notable differentiation in the dentition. The incisors and canines are conical, the premolars are simple, and the brachyodont molars in the upper jaw tritubercular, and in the lower "tritubercular-sectorial." If it were possible to breathe life again into the animals of the Cernays and Puerco period, and to transplant them amongst the existing mammalian fauna, any zoologist would be very likely to group the Creodontia, Condylarthra, Pachylemuria, and Amblypoda of that period together into one single order, although they undoubtedly represent the primitive forerunners of four, subsequently strongly-differentiated, groups. This growth of different stems from a common root, forms one of the strongest arguments in favour of the descent-theory, although it is also at the same time no small difficulty in the way of classification. If the Older Eocene mammals had not been further developed and differentiated, we should probably have distinguished only two orders of Placental mammals, of which one would be the Tillodontia, and the other would include all the remaining forms.

---

[1] Lemoine, V. Étude d'ensemble sur les dents des Mammifères fossiles des environs de Reims. Bull. Soc. Géol. de France, 1891, 3 ser. xix. pp. 263–290.

[2] Cope, E. D., Synopsis of the Vertebrate Fauna of the Puerco Series. Trans. Amer. Philos. Soc. 1888, xvi.

Already in the succeeding zone of the Older Eocene, to which in Europe the London Clay of England, the Lower Sand, the Plastic Clay and Lignite of the Paris basin, belong, as well as also the so-called Wasatch or Coryphodon beds of Wyoming, Utah and New Mexico, in North America, the character of the Mammalian fauna has not inconsiderably been changed. The Allotheria have disappeared. The Creodontia have much increased in size, and are greatly differentiated, and they have already received a carnivorous stamp. Amongst the Ungulates, Amblypoda, Condylarthra, and the Perissodactyla are very distinctly separated; there are some rare and primitive forerunners of the Artiodactyla; the Prosimiæ (Pachylemuridæ) are numerous, and the Rodents and Tillodonts are represented by typical and strongly-differentiated genera. The genera of this horizon, known up to the present, are distributed in Europe and North America, as follows:—

CONDYLARTHRA.

EUROPE.	NORTH AMERICA.
†*Phenacodus.*[1]	**Phenacodus.**
†*Protogonia.*	*Protogonia.*
†*Meniscodon.*	**Meniscotherium.**
†*Periptychus.*	*Hyracops.*

---

[1] The forms thus marked (†) are known only from the Bohnerz of Switzerland; those printed in thick type are the specially characteristic and most numerously represented genera.

PERISSODACTYLA.

EUROPE.	NORTH AMERICA.
Hyracotherium.	**Hyracotherium.**
Pachynolophus.	*Pachynolophus.*
Lophiodon.	*Eohippus.*
Brachydiastematotherium.	*Heptodon.*
	Systemodon.
	Lambdotherium.

ARTIODACTYLA.

Lophiodochœrus.	*Pantolestes.*
Protodichobune.	

AMBLYPODA.

Coryphodon.	**Coryphodon.**
	Manteodon.
	Ectacodon.

TILLODONTIA.

Esthonyx.	**Esthonyx.**
(*Platychœrops.*)	**Calamodon.**
†*Calamodon.*	*Stylinodon.*
	Dryptodon.
	? *Ectoganus.*

RODENTIA.

Decticadapis.	*Paramys.*

INSECTIVORA.

Adapisoriculus.	*Diacodon.*
	Centetodon.

CREODONTIA.

Palæonictis.	**Palæonictis.**
†**Proviverra.**	**Oxyæna.**
†*Cynohyænodon.*	*Amblyctonus.*
†*Ailuravus.*	**Pachyæna.**
? *Argillotherium.*	*Anacodon.*
	Sinopa.
	Didelphodus.
	Dissacus.
	Miacis.
	Didymictis.

PROSIMIÆ (PACHYLEMURIDÆ).

†*Pelycodus.*	**Pelycodus.**
†*Hyopsodus.*	**Hyopsodus.**
	Lemuravus.
	Microsyops.
	Tomitherium.
	Anaptomorphus.
	Mixodectes.
	Cynodontomys.
	? *Sarcolemur.*
	? *Apheliscus.*
	? *Opisthotomus.*

If we compare with each other the Mammalian faunas living in the Older Tertiary period in these widely separated regions, we are at once struck by the contrast of the poverty in genera and species of the European region with the abundance in the American localities. If we consider, however, that the few areas in Europe yielding the materials of this fauna are of very limited extent in Northern France, England and Switzerland, whilst in Wyoming, Utah and New Mexico the Older Tertiary fresh-water beds cover hundreds of square miles and are quite open to investigation, we need not relinquish the hope of future fresh discoveries in Europe. The excellent researches of Rütimeyer[1] on the Bohnerz fauna of Switzerland have moreover shown that during the Eocene period an unexpected number of genera of a distinctly American stamp lived in Europe. The fissures in the Jurassic Limestones filled with mud and ferruginous-concretions (Bohnerz), in which these forms were preserved, cannot be directly compared with ordinary sedimentary strata. Their infilling was probably a very slow process; it plainly began during the Older Eocene period and continued to its close. The Bohnerz fauna of Switzerland has, therefore, no individual character; forms of Old-Eocene type are mingled in it with those of the Middle and Upper Eocene. The earlier forms are, as a rule, only indicated by a few isolated teeth, but they nevertheless serve to show that several genera, hitherto held to be indigenous to America, lived also in Europe. And this fact is of great importance, since it proves not only the unity of origin of the Older Eocene fauna, but also the former connection of two regions of distribution, now sharply separated.

II. Middle Eocene.

The conditions of preservation were still more unfavourable in Europe during the Middle Eocene than previously. The neighbourhood of Paris, the fresh-water deposits of Argenton (Indre), Bracklesham (Sussex), Issel (Aude), Buchsweiler (Alsace), and some few other scattered localities have yielded the scanty remains of a mammalian fauna, amongst which may be named the Perissodactylous genera *Lophiodon*, *Palæotapirus*, *Propalæotherium*, *Paloplotherium*, *Hyracotherium*, *Pachynolophus*, *Pernatherium*, the Artiodactyle *Dichobune* and the Creodont genus *Proviverra*. The teeth and fragmentary bones and jaws which have been washed together into the Bohnerz fissures of the Swiss Jura at Egerkingen, Gösgen, Mauremont and St. Loup, would have better revealed the composition of the Middle Eocene mammalia, if they had not contained a commingling of remains from all the other divisions of the Eocene period. A comparison with the American area, where the renowned Bridger or *Dinoceras*-beds of Wyoming are filled with beautifully preserved mammals, is beset with great difficulty for want of material. Fresh finds in Europe may yet yield further forms of an American type, since all our Middle Eocene genera possess in the Bridger beds, either representative forms or are themselves directly represented by slightly different species. The Bridger beds contain the following genera:[2]

MARSUPIALIA.
Didelphys.

PERISSODACTYLA.
Hyracotherium.
Eohippus.
Pachynolophus.
(*Orohippus.*)
? *Helohippus.*
Epihippus.
Lambdotherium.
Helaletes.
Hyrachius.
Colonoceras.
Triplopus.

---

[1] Die eocäne Säugethierwelt von Egerkingen. Abh. Schweiz. paläon. Gesellsch. 1891, Bd. xviii.

[2] The Genera most numerously represented are printed in thick type.

PERISSODACTYLA.
Amynodon.
Palaeosyops
Limnohyops.
Telmatotherium.

ARTIODACTYLA.
Achænodon.
Homacodon.
? *Oromeryx.*
Ithygrammodon.
? *Stibarus.*

AMBLYPODA.
Uintatherium.
Dinoceras.
Loxolophodon.
(*Tinoceras.*)

TILLODONTIA.
Tillotherium.
Anchippodus.

RODENTIA.
Paramys.
Mysops.
Tillomys.
Toxymys.
Colonymys.

INSECTIVORA.
Ictops.
? *Passalacodon.*
? *Anisacodon.*
? *Entomacodon.*
? *Euryacodon.*

CHIROPTERA.
Nyctilestes.
Vesperugo.
Nyctitherium.

CREODONTIA.
Mesonyx.
Proviverra.
Protopsalis.
Miacis.
Didymictis.

PROSIMIÆ.
Hyopsodus.
Tomitherium.
Omomys.
Notharctus.
Limnotherium.
Microsyops.
? *Thinolestes.*
? *Telmatolestes*, etc.

In the Middle Eocene also appear the first marine Mammals, for instance, *Zeuglodon* in North America and Europe, *Halitherium* in Europe and North Africa, and *Prorastomus* in the West Indies. The characteristic features of the Middle Eocene fauna are the great development of the Perissodactyla and the Prosimiæ, and the sudden appearance of the mighty Dinoceratidæ, at present limited to North America. The Artiodactyla, Rodents and Insectivora continue to increase, the Creodontia and Tillodontia are already on the decline, whilst the Chiroptera are known for the first time.

III. UPPER EOCENE.

In the first rank of the Upper Eocene may be reckoned the renowned fauna of the Paris gypsum-beds described by Cuvier. (By many authors it is also placed as Lower Oligocene.) Contemporaneous with this are the lignite deposits, rich in mammals, of Débruge near Apt (Vaucluse); the freshwater marls and chalky-beds of Alais and St. Hippolite (Gard), of the neighbourhood of Le Puy in Velay, and of Castelnaudary (Languedoc); of the Upper Rhine Valley (Mühlhausen, Alsace, Breisgau in Baden) and the freshwater-beds of Bembridge and Hordwell in the South of England. Numerous remains of the same fauna have been inclosed in the Bohnerz of the Swiss, Swabian and Franconian Jura (Egerkingen, Gösgen, Mauremont, Delsberg, Moutiers, Schaffhausen, Fronstetten; around Ulm, Heidenheim, Pappenheim, and other places), and, more especially, in the phosphate-bearing loam which fills the Jurassic fissures in the so-called Quercy, between Villefranche and Montauban. As already remarked, the Bohnerz and Phosphate-beds do not contain one particular fauna: in Switzerland (particularly near Egerkingen and Mauremont) there is a mingling of Old Eocene species with those from the Middle and Upper Eocene; at Quercy there is a small percentage of genuine Oligocene, and even of Lower Miocene types, associated with the Upper Eocene forms. Although, therefore, the Phosphorites contain an altogether preponderant number of Upper Eocene species, and tolerably all the Upper Eocene genera occurring elsewhere, and though, in the abundance and beautiful preservation of the remains they throw into the shade all other Upper Eocene localities, yet, in forming a judgment on the general characters of the fauna, the remains from beds deposited in a normal manner must chiefly be taken into account.

The Upper Eocene fauna in Europe includes the following genera :[1]

MARSUPIALIA.
__Didelphys.__

CONDYLARTHRA.
†_Phenacodus._
†_Protogonia._
†_Periptychus._
†_Meniscodon._

PERISSODACTYLA.
†? _Hyracotherium._
*†_Pachynolophus._
Lophiotherium.
†*_Propalæotherium._
__Palæotherium.__
__Paloplotherium.__
__Anchilophus.__
†*_Lophiodon._
*_Protapirus._
*__Cadurcotherium.__
*_Aceratherium_ (M.)
*_Schizotherium._
*_Limognitherium._

ARTAODACTYLI.
*_Anthracotherium_ (O.)
__Ancodus.__
*†_Rhagatherium._
*_Tapirulus._
*_Elotherium_ (O.)
__Cebochœrus.__
*_Hemichœrus._
__Acotherulum.__
*_Doliochœrus._
__Chœropotamus.__
*_Palæochœrus_ (M.)
__Anoplotherium.__
__Diplobune.__
Dacrytherium.
*? _Mixochœrus._
__Dichobune.__
*_Mouillacitherium._
*_Spaniotherium._
*_Oxacron._
*_Metriotherium._
*_Deilotherium._
__Xiphodon.__
Amphimeryx.

__Dichodon.__
*†_Tetraselenodon._
*†_Haplomeryx._
*_Tragulohyus._
*__Cænotherium__ (M.)
*_Plesiomeryx_ (M.)
__Gelocus.__
__Lophiomeryx.__
*_Cryptomeryx._
*__Prodremotherium.__
*_Bachitherium._
*_Choilodon._
*_Platyprosopos._
*_Dremotherium_ (M.)

TILLODONTIA.
†_Calamodon._

RODENTIA.
*†__Sciuroides.__
*_Sciurodon._
Sciuromys.
*__Pseudosciurus.__
*†_Sciurus_ (M.)
*_Cricetodon_ (M.)
*†_Trechomys._
__Theridomys__ (O. M.)
*_Nesokerodon._
*_Protechimys._
Myoxus (M.)
*_Eomys._
__Plesiarctomys.__
*_Plesiospermophilus._

INSECTIVORA.
*_Myxomyogale._
*†__Amphidozotherium.__
*_Comphotherium._
*†__Neurogymnurus.__
*_Sorex_ (M.)
*_Necrosorex._

CHIROPTERA.
*__Pseudorhinolophus.__
*_Alastor._
*_Vespertiliavus._
*_Necromantis._

__Nyctitherium.__
(_Vespertilio_).

CREODONTIA.
*? _Adracodon._
†_Mioclænus._
*_Quercytherium._
__Proviverra.__
Galethylax.
†_Prorhizæna._
*_Oxyæna._
__Hyænodon__ (O. M.)
__Pterodon.__
*_Pseudopterodon._
*_Thereutherium._
†_Cynohyænodon._

CARNIVORA VERA.
(Fissipedia.)
__Cynodictis.__
*†__Cynodon__ (O.)
*_Plesiocyon._
*_Pachycynodon._
*_Amphicynodon_ (O.)
*_Cephalogale_ (M.)
*†_Pseudamphicyon._
*†_Brachycyon._
*__Stenoplesictis.__
*__Palæoprionodon.__
*_Haplogale_ (M.)
*_Stenogale_ (M.)
*__Plesictis__ (O. M.)
Palæogale (M.)
*_Amphictis_ (M.)
Viverra (M.)
*__Ælurictis.__
*†__Pseudælurus__ (M.)
*__Eusmilus.__

PROSIMIÆ.
__Adapis.__
*__Necrolemur.__
Microchœrus.
*_Heterohyus._
*_Cryptopithecus._
†_Pelycodus._
†_Hyopsodus._

---

[1] The genera occurring in the Phosphate-beds only are marked with a *, those in the Swiss Bohnerz only with a †; those present both in the Phosphorites and the Bohnerz with *†. To the genera also occurring in the Oligocene an (O.), and to those in the Lower Miocene an (M.) is affixed. The specially abundant or characteristic genera are printed in thick type.

A comparison of this fauna (from which the genera from Egerkingen marked with † may properly be excluded) with that of the Lower and Middle Eocene of the same areas of distribution, shows a much greater abundance of genera (about 110) and species (about 200). Supposing that ten per cent. of the genera and species have only provisional value, and that they will disappear with more ample knowledge, there yet remains a varied and numerous company of animals such as to-day would only be met with in tropical regions. Our present European land mammalian fauna contains 54 genera with about 150 species, and of these about 60 per cent. belong to the microfauna consisting of the smaller forms of Rodents, Insectivora, Bats and Carnivora, for which the conditions of preservation in earlier epochs were very unfavourable. The Ungulates still play the leading part in the Upper Eocene, but the Perissodactyla have resigned their advanced position to the Artiodactyla. Amongst the former *Pachynolophus*, *Propalæotherium* and *Lophiodon* still continue, but they are inferior in number to the more modern genera *Palæotherium* and *Paloplotherium.* Amongst the Artiodactyla, nearly half the genera belong to the Anoplotheridæ, which in outer form approach nearest to the Perissodactyla, and in their dentition and build of the skeleton combine features of the Ungulata and Carnivora. They belong to the most peculiar creatures of that period. Their depressed lophodont molars call to mind the Palæotheridæ; no reduction of the canines or incisors is yet noticeable; horns or other protuberances are yet wanting on the skull; the extremities have undergone but very moderate differentiation, they always possess separated metapodials and inadaptive carpus and tarsus; and their terminal phalanges resemble the anomalous hoofs or claws of the Condylarthra. In outer form the Anoplotheridæ exhibit great variation. Whilst *Anoplotherium*, *Diplobune* and their relatives are similar to a Tapir, to which a very long tail has been added, *Dichobune*, *Xiphodon*, and others, call to mind slimly formed deer, and the delicate four-toed Cænotheriæ, which continued into the Miocene, varied in size between a Squirrel and a Cat. Next to the Anoplotheridæ, the Tragulidæ form the main contingent of the paired ungulates. Their dentition has almost attained the character of that of the brachyodont Ruminants, and in the structure of their skeleton and more especially of the extremities, they hardly remain behind the still existing Chevrotains, which in a certain measure, may be considered as relicts of an earlier epoch, since amongst all Ruminants they possess the most primitive features. The Eocene Suidæ (*Cebochœrus*, *Elotherium*, *Chœropotamus*, *Palæochœrus*, *Acotherulum*, etc.), bear the same relation to existing swine as the Tragulidæ to the Cervidæ. The crowns of their bunodont molars have four simple tubercles; canines and incisors, like those of the Condylarthra and Creodontia, are but little differentiated, and the skeleton has not undergone any simplification or reduction of the extremities worth mentioning. Also the early extinct Anthracotheridæ are shown to be collective types, which connect the lophodont and bunodont Artiodactyla with each other. The scarcity of the Condylarthra and Amblypoda shows moreover that the Upper Eocene Ungulates had already reached a higher development than those immediately preceding them, and this fact is also not less evident amongst the Carnivora. The more incomplete Creodontia are, so far as wealth of form is concerned, strongly on the decline, even though *Hyænodon* and *Pterodon*, yet belong to the most numerous and strongest Carnivores of that period. Near to these an abundance of genuine Fissipede Carnivora make their appearance, which are placed with the Canidæ, Mustelidæ, and Viverridæ, but they yet possess so many features in common, that they would certainly be united into a single family if they still lived in company with their more advanced and variously differentiated descendants of the present day. Only the Cats (*Pseudœlurus*, *Eusmilus*) are already in the Eocene distinguished by sharply defined characters.

The Pachylemuridæ (*Adapis*, *Cænopithecus*, *Necrolemur*, *Microchœrus*, etc.) also form a very characteristic element of the Upper Eocene fauna; they are connected with Old Tertiary forerunners, and combine features of the existing Lemurs and genuine Apes.

The so-called micro-fauna is fairly abundantly represented by Rodents, Insectivora, Bats, and Marsupial Rats (Didelphys). The three last-named orders, anyhow, contain species without specially noticeable characteristics, so that they could very suitably still have existed, and they prove that since the beginning of the Tertiary period these groups have made but very little progress. The Rodents also form a very conservative element of the Upper Eocene group of animals. If in many points of differentiation they are behind their successors, they already possess every typical feature of the order, and they are hardly more closely connected with the representatives of other groups than their still existing descendants.

If we look round for materials for comparison with the Upper Eocene mammalia of Europe, it is to North America that we must at once again turn our view, where, resting on the richly fossiliferous Bridger beds, a filially related but impoverished fauna lies buried in the so-called Uinta or *Diplacodon* beds, in which the Amblypoda and Tillodontia have disappeared, the Perissodactyla (*Pachynolophus*, *Triplopus*, *Isectolophus*, *Diplacodon*, *Amynodon*), the Artiodactyla (*Protoreodon*, *Leptotragulus*), and the Creodontia (*Mesonyx*, *Miacis*), claim pre-eminence, and Rodents and Prosimiæ appear, at least, to be indicated by scanty remains. A detailed comparison of the contents of the Bridger and Uinta-beds with the Middle and Upper Eocene mammals of Europe would certainly yield a variety of parallels, but it would at the same time also show that common genera or representative members of the same group appear with less frequency than in the Older Eocene. Only a few names are repeated in the European and American lists (*Didelphys*, *Hyracotherium*, *Pachynolophus*, *Nyctitherium*, *Proviverra*), but on deeper search it would be found that several European genera turn up again in the Western hemisphere in a shallow disguise. Thus, for example, the genera *Helatetes* and *Isectolophus* take the place of the European *Lophiodon* and *Protapirus*; *Cadurcotherium* is replaced by *Amynodon*;

Plesiarctomys by *Paramys*; the European Lemurs, Bats, and Insectivora, for the most part have nearly related representative genera in North America, and for the Anoplotheridæ and Tragulidæ a substitute may be found in the altogether different Leptotragulidæ.

The development of the animals on both continents has evidently always followed different roads. The connection of the two continents appears, indeed, to have been still maintained, but the means of communication must have been difficult.

(*To be continued in our next Number.*)

NOTICES OF MEMOIRS.

I.—WESTERN AUSTRALIA. REPORT ON THE MURCHISON GOLDFIELD. By HARRY PAGE WOODWARD, F.G.S., etc., Government Geologist. 8vo. pp. 21. (Perth, 1893.)

THIS goldfield has a proclaimed area of 32,000 square miles. The principal auriferous belt is at its eastern side, about 200 miles from the coast, and has a general N. and S. direction. Other rich patches and belts occur further east (probably to a great distance), and a few nearer the coast. The metamorphic rocks constitute the base of this area, such as slates and schists, talcose, hornblendic, and micaceous, besides granite and highly altered ferruginous jaspery quartzites. These are traversed by large quartz-reefs, which are richest where intersecting the quartzite. There are also limestone beds, with veins of ferruginous calcite, bearing some gold. These rocks strike a little W. of N., dipping to the W., and in the northern part of the field turn N.E. and E., with granitic, dioritic, and other dykes.

On them lie remnants of an old table-land of the Mesozoic "Desert Sandstone" of Australia, consisting of horizontally bedded sandstones, clays, pipeclays, gypsum, and ferruginous layers. The alluvium in the water-courses, flats, and salt-marshes rarely exceeds 20 feet in thickness; there is also local travertine and other surface deposits. The alluvium has been derived largely from the Desert Sandstone, and partly from the metamorphic rocks; the latter *débris*, coarse and stony, sometimes overlies the former, because these older rocks were exposed to denudation after the Sandstones; hence the auriferous "wash" is not always on the true bottom; nor does it usually run in "leads," not having been shifted and sorted by running water. Definite "gutters," however, were found on the bed-rock at Lake-Austin Island and at Quin's.

The "reefs" have a high dip; and, where opened down to the water-level, often contain galena as well as iron-pyrites; in some cases copper-pyrites and antimony. For the most part they seem to be "fissure-veins," of variable size and extent. They have "shoots," or small parallel fissure-veins; and there are also "cross-courses," rich at their intersection of main north-and-south reefs, such as the "Star of the East," a true lode, but much broken.

The water-supply is good for the most part; excepting at the

Salt Lakes, Lake Austin, and elsewhere. The water-level in the mines is usually within 100 feet depth. Timber, however, is relatively scarce. The roads are bad at present.

Some large auriferous ironstone lodes are also met with, hematitic at top and pyritous below. In the Weld Range the exposed hematite is botryoidal, giving rise to the local opinion that it was a lava-flood. In some of the soft clayey bands of these lodes the Kangaroos scratch out caves; and the natives probably followed this plan in getting at the lode itself centuries ago, and here they still work (for the whites) with primitive wooden tools, cutting round a mass of the ore and then wedging it off. This ironstone was worked on a larger scale, and probably traded to great distances, before the white invasion of Western Australia. The red ochre of the lode has been mistaken for cinnabar.

The several mines and diggings are described in detail (pages 12–21); and, in conclusion, this Goldfield is regarded as exceedingly rich, and to have a brighter out-look than any other in the Colony; the distance to be traversed in getting to Kimberley, and the salt water of Yilgarn, being disadvantageous to them. Pilbarra and the Ashburton have not been proved to be large reefing districts.

T. R. J.

II.—On the Cranial Osteology of the Mesozoic Ganoid Fishes, *Lepidotus* and *Dapedius*. By A. Smith Woodward, F.G.S., F.Z.S.[1]

In this paper the author describes the cranial osteology of *Lepidotus*, so far as decipherable from specimens discovered by Mr. Alfred N. Leeds in the Oxford Clay of Peterborough, and from Wealden specimens in the collection of the late Mr. S. H. Beckles. He then compares the skull with that of *Dapedius*, as shown by a fine specimen from the Lower Lias of Lyme Regis in the British Museum.

From the observations recorded it would be premature to make any very general deductions, the characters of the skull having yet to be discovered in the majority of the Mesozoic fishes. The new facts, however, are interesting as tending to confirm a conclusion that must have impressed everyone who has deeply studied these extinct fishes, namely, that it is impossible in Jurassic and Cretaceous formations to recognise any absolute sub division of the so-called ganoids into "Lepidosteoidei" and "Amioidei." The skulls of *Lepidosteus* and *Dapedius* differ from those of existing "ganoids" in exhibiting the backward extension of the basicranial canal; and the cartilaginous cranium of *Dapedius* is remarkably similar in every respect to that of the modern salmon (*Salmo*), except somewhat more ossified. Both *Lepidotus* and *Dapedius* agree with *Lepidosteus* and *Amia* in the fact that the membrane bones of the roof do not extend quite to the occipital border of the cranium; but *Dapedius* at least is distinguished from *Amia* and approximated to *Lepidosteus* by the course of the olfactory nerves across the orbital cavity, while *Lepidotus* is paralleled only by the last-named genus in the absence of a gular plate. On the other hand, the superficial bones of the two extinct genera differ greatly from those of *Lepidosteus* and closely resemble those of *Amia*; the peculiar attachment of the premaxillæ in *Lepidotus*, for example, being reproduced almost in every detail in the last-named genus.

---

[1] Abstract of paper read before the Zoological Society, June 20th, 1893.

III.—ON THE DENTITION OF A GIGANTIC EXTINCT SPECIES OF *MYLIOBATIS* FROM THE LOWER TERTIARY FORMATION OF EGYPT.

By A. Smith Woodward, F.G.S., F.Z.S.[1]

THE Skates of the family of Myliobatidæ are well known to attain a great size, but few examples even of the dentition of the largest specimens are preserved in museums. It is, therefore, of much interest to record that the British Museum has lately received from Surgeon-Captain R. H. Penton a good example of the jaws of one of the most gigantic extinct species of *Myliobatis*, discovered in the Lower Tertiary Limestone of the Mokattam Hills, near Cairo, Egypt. So far as the present writer is aware, this is the largest specimen of the dentition of *Myliobatis* that has hitherto reached any museum.

The jaws were found in natural association, and the size of the teeth is indicated by the following table of measurements in fractions of a metre:—

	UPPER DENTITION.	LOWER DENTITION.
Width of median dental plate... ...	0·13 to 0·135	0·12 to 0·13
Length ,, ,, ...	0·18	0·014 to 0·016
Maximum width of three lateral series of plates...	0·02	0·02

From these measurements it is evident that the principal teeth in the lower jaw are about eight times, those of the upper jaw about seven and a half times as broad as long; while the maximum thickness of the same teeth in both jaws equals nearly one-quarter of their breadth. These characters, taken in conjunction with the form and proportions of the lateral teeth, suffice to distinguish the Makattam specimen from the dentition of all known species of *Myliobatis*; and it may therefore be named *M. Pentoni* in honour of its discoverer. In determining such specimens it is, of course, necessary to take into account the mode of growth of the teeth and their change in proportion with age; but it does not appear possible, in accordance with the ordinary laws of growth, for any known type of dentition to develop by increase of size into the one now described. The form of the lateral teeth and the transverse section of the median teeth seem to be nearly constant at all stages of growth in any one species.

Materials for comparison are unfortunately insufficient to form any certain estimate of the size of *Myliobatis Pentoni*; but if the few small examples of the recent *Myliobatis aquila* in the British Museum are at all similar in proportions, the maximum width of the disc of the extinct species cannot have been much less than five metres.

---

[1] Abstract of paper read before the Zoological Society, June 20th, 1893.

REVIEWS.

I.—Memoirs of the Geological Survey of the United Kingdom. The Jurassic Rocks of Britain. By C. Fox-Strangways, F.G.S. Vol. I., Yorkshire, pp. 551, including Index, price 8*s.* 6*d.* Vol. II. (Yorkshire) Tables of Fossils, pp. 250, price 12*s.* 1892. London: Kegan Paul, Trench, Trübner and Co., Limited.

AFTER a brief outline of the physical features of the district and the system of classification adopted, Mr. Strangways draws attention to the progress of geological enquiry with reference to the Jurassic rocks of Yorkshire. This piece of historical geology is not without interest to the general reader, since there is a touch of quaintness in the attempts of the earlier observers to account for so many natural curiosities. East Yorkshire, moreover, even before the days of Phillips, had attracted the notice of William Smith, the father of stratigraphical palæontology, and the genuine Yorkshireman may comfort himself with the reflection that this line of observation, which is the very backbone of geological science, was as much impressed on Smith's mind by an inspection of the Hambletons and the Howardians as by that of the Cotteswolds themselves. These hills, then, may share with the Cotteswolds the honour of having cradled the infant science, which found its first expression in "Strata identified by organized fossils." The region was subsequently rendered classic ground through the publications of Phillips, who brought the geology of East Yorkshire well to the front some sixty-four years ago.

To survey such a district and to write the official memoir on its geology was no unpleasant, if no very easy task. There is much that is difficult in the stratigraphy of certain parts of East Yorkshire, yet nothing that can be called absolutely obscure. The beds, too, vary both within the district itself, and also as a whole by comparison with those of other parts of England, yet not to such an extent but what they may be correlated. Hence the difficulties are not insuperable, yet sufficient to give zest to the enquiry and to yield credit when they have been fairly surmounted. The author commenced operations about the time when a long lull in the geological investigation of East Yorkshire had been succeeded by a period of awakening interest. The classical volume of Phillips possessed all the charm which usually belongs to a pioneer's work; whilst to the average compiler it seemed to have told the tale so completely that there was nothing left for the next generation but to accept without question his reading of the rocks. Yet there had long been doubts in some quarters as to the precise value of certain of Phillips' conclusions, and these doubts had found a partial expression in the writings of Oppel and Wright. The publication of the Survey Memoir on the Jurassic Rocks of the Midlands by Prof. Judd, the series of papers by Mr. Hudleston in the Proceedings of the Geologists' Association and the important work on the Yorkshire Lias by Messrs. Tate and Blake, all proceeded on the basis of original and independent investigation, free from too close an imitation of antecedent opinion. Thus Mr. Strangways appeared on the scene at a very opportune moment, when the ground had to a certain extent been cleared, in anticipation, as it were, of his more complete and systematic survey.

His maps, which have appeared at intervals for several years past, must be regarded as a summary of the stratigraphy of the district and speak for themselves. It only remains for us to briefly notice his method of dealing with the Jurassic rocks of Yorkshire in the volumes now before us. The Introduction contains tables showing—(1) the various divisions of these rocks adopted at different periods, and (2) a comparative table of foreign equivalent formations. As regards the Palæontological equivalents here adopted we may remark that there appears a complete blank between the zone of *Am. plicatilis* (Corallian) and the zone of *Bel. lateralis*, which latter is almost post-Jurassic; nor is the division between Upper and Lower Kimeridge recognized in the Table, perhaps from the difficulty of drawing a line. Whilst on this subject we may add that the numerous Tables of Sections, etc., throughout vol. i. add greatly to the interest and value of the work.

The Lias occupies three chapters (119 pages), preceded by a table showing the zones into which the Lias of Yorkshire has been divided, its chief lithological divisions, etc. Each zone is then dealt with in detail, and a few of the characteristic fossils figured—and perhaps the figures might have been rather better. The present classification is somewhat changed from that adopted by the Survey in 1880; the Lower Lias is held to range from the *planorbis*-zone to the *capricornus*-zone; the Middle Lias comprises the *margaritatus*-zone (Sandy Series) and *spinatus*-zone (Ironstone Series); the Upper Lias is in four zones, from the *annulatus*-zone to the *jurensis*-zone inclusive. One of the most interesting and important features in connection with the Yorkshire Lias is the development of the Ironstone Series, of which full details are supplied. Taking Eston as the point of departure, sections are given showing the thickness and range of the seams of ironstone in three directions, viz. (1) Eastwards, along the northern escarpment, and thence by the coast to near Robin Hood's Bay; (2) South-eastwards, across the interior dales; and (3) Southwards, along the western escarpment to the neighbourhood of Thirsk. It is interesting to geologists, though less so perhaps to iron-miners, to note how the main Cleveland seam appears to diminish in economic value in all directions from its bold northern outcrop at Eston.

The extraordinary character of the Lower Oolites in Yorkshire necessitates a considerable amount of division. Hence we find that this portion of the Memoir occupies no less than seven chapters (126 pages). The peculiarity of an Estuarine series which is repeatedly split up by marine bands, themselves often richly fossiliferous, requires special treatment, and the more so since these marine bands present much difference of development within the area under consideration. Thus the Millepore Bed increases in importance towards the south and dies out entirely towards the north, whilst that other great divider of the Estuarine series, the Gray or Scarborough Limestone, behaves in a manner the reverse of this. In the Howardians the equivalents of most of the marine beds, except the Cornbrash, may be recognized, but under different conditions of development.

A glance at plate iv. which illustrates the variations in thickness and mineral character of the Lower Oolites in Yorkshire, is very instructive in this connection. One cannot help noting that the 30 or 40 feet of "Estuarines" and Oolite at Kirkby Underdale, where deposit is at a minimum, practically mark the southern margin of what we may regard as the Yorkshire basin of deposition. From this point we perceive a somewhat irregular increase in a northerly direction until at least 700 feet of beds are recorded, exclusive of the Blea Wyke Beds, which would add some 70 feet more to the score of the Lower Oolites. It is almost needless to add that the details are well worked out in the text, and present many features of great interest alike to those who are acquainted with the district and to those desirous of becoming so.

The Middle Oolites, from the Kellaways Rock to the uppermost Corallian inclusive, are disposed of in three chapters (98 pages). Of course it is well known to students of Jurassic geology that "Kellaways Rock" and "Oxford Clay" in Yorkshire mean something very different from what these names imply in the south of England. This discrepancy arises from the necessity of adopting a lithological rather than a palæontological basis of subdivision in mapping the country. A glance at table v. of this memoir will show what a very subordinate part the "Oxford Clay" plays in many portions of the interior of the county. Throughout the Tabular range, in fact, until we approach the coast, it is nothing more than a few feet of sandy clay between two powerful arenaceous formations, the Kellaways Rock below, and the Lower Calcareous Grit above. Here also, as in the case of the Lower Oolites, we perceive a minimum of deposition as the southern margin of the Yorkshire Basin is approached at Acklam.

The Corallian Series, which constitutes the upper member of the Middle Oolites, is exceptionally well developed in Yorkshire. Mr. Strangways recognizes the two palæontological divisions of this series, which had been indicated by Messrs Blake and Hudleston, in their paper on the "Corallian Rocks of England" (Q.J.G.S. vol. xxxiii.). The lower division, which may be regarded as Upper Oxfordian, is the zone of *Am. Perarmatus* and includes the Lower Calcareous Grit. the Passage Beds, and the great series known as the Lower Limestone, although the top shell-bed of that formation gives indications of the change in the fauna which obtains in the higher beds. This may generally be distinguished from the Upper Limestone (Coralline Oolite and Coral Rag) by the prevalence of *Gervillia* instead of *Chemnitzia* (*Pseudomelania*). The two limestones are not easy to separate in the Howardian Hills, although at Appleton the fauna of the Passage Beds is clearly to be recognized. The solidarity of the two limestones in the Howardians is certainly in favour of regarding all the beds above the Lower Calcareous Grit and below the Kimeridge Clay as parts of one system.

The zone of *Am. plicatilis* is held to include the Middle Calcareous Grit, where these beds are developed, as in the Hambleton and Tabular Hills, the Upper Limestone, and the Upper Calcareous Grit, together with its equivalent, the Cement-stone Beds of the eastern portion of the Howardians. As a matter of fact the Upper Calcareous Grit is non-existent in the Howardians, since the unexpected and exceptional development of Upper Calcareous Grit at Coxwold can scarcely be placed in this system of hills. The delimination of the Middle Calcareous Grit forms an important part of Mr. Strangways' work, the more so as the existence of this independent arenaceous series was never suspected by Phillips and the earlier geologists. He enumerates the fossils of the *Trigonia*-beds at Pickering along with those of the Middle Calcareous Grit, and notes the possibility of this horizon occurring at Middle Cave, near Malton, although it would, of course, be impossible to indicate on a map anything like Middle Calcareous Grit in the Howardians.

In dealing with the inner margin of calcareous rock which girdles the Vale of Pickering he indicates the possibility of a separate origin for the Coral Rag of the Ayton district from that of Pickering and the westward. The Coral Rag, in its typical form, rather fails about Pickering, being possibly represented by obscure calcareous beds, but as we go westwards towards Oswaldkirk a great variety of Coral-rock obtains and the sides of the quarries often present beautiful arabesques where the structure has been brought out by weathering. On the opposite side of the Vale, at North Grimston, the Coral Rag would seem to have attained its maximum development, but rapidly thins out southwards to complete extinction. The relations of this rock to the overlying cement-stone, chiefly formed from its denudation, and of both of them to the Kimeridge Clay above and the Lower Calcareous Grit below, constitute an episode in stratigraphy which renders the Birdsall district one peculiarly difficult of interpretation.

The Upper Oolites are dismissed somewhat briefly, one chapter of a dozen pages being all that is devoted to their consideration. Practically, the Upper Oolites in Yorkshire consist of the Kimeridge Clay, since the beds, recently distinguished as the zone of *Bel. lateralis*, have no title to be considered Portlandian, though they may possibly represent *in time* a portion of the Purbeck series.

It would seem that the mystery which has so long attached to the Kimeridge Clay of Yorkshire is still unsolved, and that no conclusive information is available as to what underlies those portions of the Vale of Pickering which lie between the great bounding faults. Mr. Strangways questions how far it is possible to trace the accepted divisions of the Kimeridge Clay in Yorkshire, the outcrop being usually covered by alluvium, "so that it is only in a few obscure sections in Filey Bay, at a few places towards the western end of the Vale of Pickering and along the western escarpment of the Wolds, which is much slipped and confused, that we get exposures of the beds."

The Upper Kimeridge consists of alternations of finely laminated, dark, bituminous and lighter shale, with hard brown bands, which have received special notice as forming the lower portion of the Speeton section. There is also a trace of the Upper Kimeridge at Settrington. All other exposures are in beds which must be referred to the Lower Kimeridge, which consists mainly of blue clays and shales with septaria. Some light has been thrown on the subject by boring at Irton: there are also feeble indications in the Vale of Pickering and the lowest slopes of the Tabular Hills. Undoubtedly the best section in the Lower Kimeridge was afforded by Sir C. Strickland's brickyard at Hildenley, three miles west of Malton, which yielded a most characteristic basal Kimeridge fauna, and there have also been a few fossils picked up on the Wold slopes, which clearly belong to the Lower Kimeridge. On the whole, however, the fauna of the Yorkshire Kimeridge seems somewhat meagre, and when we find (p. 381) *Rhynchonella inconstans* quoted as a "Portlandian" fossil, we can only express surprise that a form, which in the South of England is eminently characteristic of the very lowest Kimeridgian, should here be found on such a high horizon.

In chapters devoted to "Physical History" and "Scenery and Denudation" the author summarizes his experiences in accordance with his own views. Under the former heading he states his belief that the beds of the Yorkshire Lias were formed in a somewhat land-locked area, having its shore-line towards the north-west, whilst lying open towards the east. The South Yorkshire deposits were formed beyond this district, and constitute the northern limits of a more extended area. Towards the close of the Liassic period the bed of the sea was elevated, or the water became shallower from the gradual accumulation of material. In the west the upper part of the Lias has been subjected to considerable local denudation, whilst on the coast the Blea Wyke beds exhibit a considerable thickness of sandy shales with *Serpulæ, Trigoniæ*, etc., showing shallow-water conditions and forming a gradual passage from the Lias below. The exceptional preservation of these beds constitutes one of the most obscure problems in the physical history of the Yorkshire Jurassics, and Mr. Strangways, in this chapter, rather favours an explanation which he has elsewhere opposed.

The physical history of the Lower and Middle Oolites appears to afford evidence of a series of oscillations throughout the period, with sediment invading the area mainly from the west and north, in which direction the shore-line probably lay. The last discharge of mechanical sediment is recorded by the Middle Calcareous Grit, even after corals had begun to form in the area; but at last there came a cessation of mechanical impurities and a large extent of organic rock with corals concluded a phase in the history of the district. The peculiar marginal character of the Corallian limestones, forming an imperfect ring as they do round the clays of the Vale of Pickering, is attributed, and we think rightly, to the accidents of stratigraphy rather than to original deposition in that form. But until the boring-rod has perforated the central mass of Kimeridge Clay in the Vale, the problem cannot be regarded as completely solved.

The general connection which exists between "Scenery and Denudation" has exercised the mind of many a field geologist; yet, as Mr. Strangways truly observes, there are few districts in England where the simplest forms of denudation are more clearly exposed than in the Tabular Hills and along the sea-coast; and he takes care to point out that the inequalities of the surface are mainly due to erosion, or to what some of the provincials would term "a wash out." He lays much stress upon initial direction in the formation of valleys and gorges, as being due to the original slope resulting from stratigraphical conditions. Since a large portion of the Jurassic rocks slope inwards towards the Vale of Pickering, a sort of horseshoe arrangement is the result, and many interesting cases are cited.

No one at this time of day is likely to call in question the general proposition that the valleys and gorges which are found in this district result mainly from meteoric denudation; but the period during which such sculpturing has been effected is not always equally clear, and there are two well-known and extremely interesting cases, where the conclusions of Mr. Strangways appear not a little startling. One of these cases relates to the Derwent as it enters the Vale of Pickering, the other to the Derwent as it leaves the Vale, where it becomes the sole conduit of the accumulated waters of so many springs and brooks.

To appreciate these points fully one ought to know the district. But it may suffice to say that the Upper Derwent, in its course from the higher moorlands, after flowing past Hackness, enters a tolerably wide valley, which has a general easterly direction and leads to the sea-coast in about five miles. This Scalby valley has all the appearance of being the true continuation of the Valley of the Derwent, and Mr. Strangways points out that the natural tendency of the original stream would be towards the east at this spot, owing to a local anticlinal axis. In fact he has no doubt that this was the old course of the Upper Derwent. Yet to the surprise of everybody who has visited the spot, the Derwent, instead of following a good wide valley almost straight to the sea, has taken the trouble to cut a narrow gorge some 300 feet deep and one-and-a-half miles in length through the Middle Oolites, direct for the Vale of Pickering, and almost at right angles to what seems to have been its previous course. He considers that this result has been attained through the damming up of the lower end of the Scalby valley by glacial deposits, or possibly by the North Sea ice itself. If the whole of this amount of work was done since the commencement of the principal glaciation, we are fain to suppose that no inconsiderable portion of the sculpture of the country has been effected in Pleistocene times.

The case of the long and sinuous breach in the Howardians by which the Lower Derwent escapes into the Vale of York is somewhat analogous, as he considers that this has been effected by the waters of the Pleistocene lake, caused by the damming up of the eastern end of the Vale of Pickering at Filey, which is still blocked by glacial deposits. Undoubtedly the Vale of Pickering held a lake, but if a 200 feet gorge has been cut through the entire breadth of the Howardians within the period claimed, even allowing for a pre-existing stream flowing towards the Vale, we must again acknowledge the immense amount of erosion which has been effected in Pleistocene times.

Attention is also drawn to this subject in reference to Cleveland, where the Jurassic rocks are encumbered by glacial deposits to a greater extent than elsewhere in East Yorkshire. One of the most characteristic features of this district is the number of rock gorges through which the existing streams flow, and which are due to the blocking of pre-glacial valleys by drift. Important inferences are drawn from the distribution of this drift throughout the Jurassic area. It is seen to cover a great part of the country north of the Esk, and in this region attains to considerable elevations. But neither over the high Moorlands south of that valley, nor throughout the Tabular Hills, has any been found, until we come to the local Drift of the lower slopes, which border the Vale of Pickering. From these facts he infers that the ice of the North Sea, impinging upon the coast of Cleveland, pushed its way nearly to the axis of the Jurassic highlands, and then divided into two streams, the westerly one moving down the Vale of York, whilst that to the east inclined to follow the coast-line. Clearly Mr. Strangways is not afraid of the "Glacial Nightmare."

Two chapters on Economic Geology conclude the first volume. The second volume is devoted to a most elaborate series of tables of fossils, prefaced by a very complete bibliography. The author observes that this catalogue was originally compiled, on a smaller scale, to facilitate the work of the Geological Survey, but that, having been found very useful in that connection, he considered its publication might be of some utility to students of this district. In this view we cordially agree, and we heartily congratulate Mr. Strangways on the completion of the entire Monograph.

II.—The Lower Silurian Brachiopoda of Minnesota. By N. H. Winchell and Charles Schuchert. Extracted from Vol. III. of the Final Report of the Minnesota Geological Survey. Chapter V., Plates XXIX. to XXXIV., June 6th, 1893.

THE authors of this Monograph, expert, industrious brachiopodists, collected the materials for their researches on the Lower Silurian Brachiopoda of Minnesota from the Upper third of the Trenton Limestone in the vicinity of Minneapolis and the Trenton shales near St. Paul's and Minneapolis. They adopt the names brachial=ventral, and pedicle=dorsal valves, and give clear and useful definitions of other terms employed. Hyatt's nomenclature is used for ontogenetical inquiries, for which, in some instances, abundant material was forthcoming. The classification agrees with that recently proposed by Schuchert, embodying Beecher's orders.

Waagen's sub-orders in part and generic emendations of Hall and Clarke.

Various species of *Lingula* are described, and it is held that the stages of growth indicate that the course of development of that genus was from *Paterina-Obolella-Lingula*. The allied sub-genus *Glossina*, Phillips, is restricted to the Palæozoic rocks. The author's new family, *Lingulasmatidæ*, is again defined. It comprises, at present, only two genera; one, *Lingulasma*, removed from the *Lingulidæ*, and the other, *Lingulops*, taken from the *Trimerellidæ*. They are the only Linguloids in which interior platforms are developed recalling the same structures in the *Trimerellidæ* which, however, Winchell and Schuchert do not regard as their direct descendants. They hold the *Lingulasmatidæ* to be a branch of *Lingula*, which originated in the Trenton times and terminated in the Niagara period. They were derived from *Obolella*, while *Monomorella* and *Trimerella* had *their* origin in *Dinobolus*. A small species of this genus (*Dinobolus? parvus*, Whitfield) occurs in the Galena formation of Wisconsin and Minnesota. It is allied to *D. Schmidti*, King and Davidson, from an Esthonian stratum almost equivalent in age with the Trenton Limestone of New York.

Several neotrematous and protrematous genera are discussed and new species and varieties proposed, among them a species of *Hallina* named *H. Nicolleti*, W. and S., after "Jean Nicollet, Geographer and Geologist of the North-West." It appears, however, that this supposed new species is considered by Hall and Clarke to be nothing more than *Atrypa exigua*, of which *Zygospira? aquila*, Sardeson, is also a synonym. All the species of the genus *Hallina*, W. and S., have been subjected to critical analysis on p. 151 of the first fascicle of part ii., volume viii., of the Palæontology of New York, issued July, 1893.[1] In this instalment of the second volume of their great work on Palæozoic Brachiopoda, Hall and Clarke announced the genus *Hallina* (type H. Saffordi, W. and S.) to be founded on incomplete preparations of a well-known shell. Hence these authorities are unable to recognise its terebratuloid characters, as it presents the main features of a Zygospiroid. For the smooth *Atrypa exigua*=*Hallina Nicolleti* the term Protozyga is proposed and its cyclospiroid affinities are recognised.

Mr. C. Schuchert has since abandoned the genus *Hallina*, in a communication published in the "Proceedings of the Biological Society of Washington," dated July 13th, 1893.[2] In conjunction with Dr. Beecher he announces his conviction that species of supposed Silurian primitive impunctate terebratuloids referred to *Hallina* and *Macandrevia* are spire-bearing forms, of which the earliest known genus is *Zygospira* occuring in the Bird's Eye limestone of the Trenton period. The details of the development of its spiral loop are discussed. It begins life as a simple centronelloid and is characterized by subsequent progression from one to six whorls in each spiral. Beecher and Schuchert express the opinion that the ontogeny and phylogeny of *Zygospira* indicate the derivation of the *Atrypidae* from forms with a centronelloid loop, consequently "the Ancylobrachia are older and more primitive than the Helicopegmata." In a secondary communication published the same date[1] Mr. Charles Schuchert discusses the development of the shell in *Zygospira recuvirostra,* for which species Davidson proposed the genus *Anazyga.* The genus *Zygospira* was founded by Hall in 1860, with *Producta modesta*, Say, as type from the Hudson River group. The genus is remarkable for the extreme variability in the position of the loop in different individuals. This variation is individual, not specific, and therefore Hall and Clarke reject Davidson's name *Anazyga* for the species *recurvirostra* of the genus *Zygospira.* According to Schuchert, the fourth stage of shell development is reached before the species "is recognizable as belonging to the suborder Rostracea, and apparently most closely related to the Rhynchonellidæ. The calcareous brachial supports make their appearance in a specimen about 1·33 mm. in length. This species is then referable to the Ancylobrachia, having a loop much like that of *Centronella.* This loop then passes through a series of metamorphoses, acquiring spirals when the shell is about 3 mm. in length."

---

[1] An introduction to the study of the genera of Palæozoic Brachiopoda. By James Hall and John M. Clarke, fascicle i., part ii., vol. viii., text and woodcuts, Albany, July, 1893.

[2] Development of the Brachial supports in *Dielasma* and *Zygospira*. By Charles E. Beecher and Charles Schuchert.

It would seem from a cursory glance through Hall and Clarke's fascicle 1. part ii. vol. viii., Palæozoic Brachiopoda, which has just reached us, that about ten new genera and sub-genera are proposed for the spire-bearing genera of Brachiopoda. 1. Many of them seem to be interesting passage forms of an inter-generic character.

Messrs. N. H. Winchell and C. Schuchert have also described and figured "Sponges, Graptolites and Corals" from the Lower Silurian of Minnesota, in chapter iii. with two plates, an excerpt from the same Report.[2] Herein the authors discuss the curious fossil sponges *Receptaculitidæ,* a family referred by that excellent authority, Dr. G. J. Hinde, to the siliceous Hexactinellid order. Their systematic position, however, has been regarded as doubtful by Nicholson, on the grounds of Rauff's discovery that the original structure of the organism was calcareous, and it became silicified subsequently. Specimens of the genus *Receptaculites* occur from four to twelve inches in diameter in the Lower Silurian of Minnesota, where they are popularly known as the "sun-flower coral of the North-West." The authors give a useful synopsis of the American species of the genera *Receptaculites* and *Ischadites,* followed by an essay on the structure of the anomalous organisms they formerly named *anomaloides,* for which they now propose the correct and more suggestive name of *Anomalospongia.* They also give figures and descriptions of a species of hydroid *Solenopora* (*S. compacta Billings*), of species of *Diplograptus* and *Climacograptus*, and proceed to discuss the madreporoid corals *Lichenaria Streptelasmidæ*, *Poritidæ*, etc., and figure and describe *Aulopora trentonensis*, W. and S., the only Lower Silurian auloporoid known. Agnes Crane.

---

[1] Development of the shell in *Zygospira recurvirostra.* By Charles Schuchert, Proc. Biol. Soc. Washington, vol. viii., pp. 71–82, pls. x., xi., July 13th, 1893.

[2] Final Report of the Minnesota Geological Survey, pp. 55–95, pls. F, G, June, 1893.

III.—Revision of the Fauna of the Marine Oligocene of the Environs of Étampes. By M. Cossmann.

Révision sommaire de la faune du terrain Oligocène Marin aux environs d'Étampes. Par M. Cossmann (Journ. de Conch. tome xxxii. pp. 330, *et sqq.*).

THIS descriptive Catalogue of the marine mollusca of the Oligocene beds to the south of Paris is a continuation of the author's work published in 1891. The whole is practically a revision of MM. Cossmann and Lambert's larger work[1] relating to the fossils of the same area; and had become necessary in view of the light thrown on the classification and nomenclature of Lower Tertiary fossils during the progress of M. Cossmann's Catalogue of the Eocene fossils of the Paris basin.

The bivalves having been disposed of in the first part, published in 1891, the section under review comprises only the Scaphopoda and Gasteropoda. Commencing with *Dentalium*, the author accepts the view of Prof. von Kœnen, that the forms hitherto referred to Hébert's *D. acutum* differ from that species, and *D. Novaki*, von Kœn., is substituted therefor.

Chiton Terquemi, Desh., is replaced by *C. Etrechyensis*, de Rocheb., the former name having been pre-occupied. M. de Rochebrune placed this species in the genus *Tonicia*, but, as M. Cossmann truly remarks, it is impossible to classify these fossils—which occur, as a rule, in single valves only, and deprived of many characteristic parts—in the same manner as their living representatives. Figures are given of *C. Poirieri*, de Rocheb., of which the anterior valve is unknown.

In his catalogue of the Eocene mollusca the author referred to the genus *Basilissa*, Watson, a certain number of shells possessing conical striæ, slightly perforated, thick peristome, with columella inflated and abruptly terminated anteriorly. On second consideration he is now disposed to include them in *Thalotia*, a subgenus of *Elenchus*. The *Trochus subcarinatus*, Lamk., of the Paris basin Oligocene possesses a columella in every way comparable with that of *Elenchus Lehmanni*, Menke, of the Australian seas, and differs only from that species in not having the lip guttered interiorly, which the author regards as an unimportant character. The embryo in both species is of the same dimensions, whilst the ornamentation of the spire is very similar, and the lip presents the same obliquity. We entirely agree with the author that the Oligocene shells under discussion are not *Basilissa*, and that they may properly be referred to *Thalotia*, but some of the thin, fragile Eocene forms appear to be identical with Watson's genus. Five species from Étampes, hitherto classed with *Trochus*, are now to be called *Elenchus*. *Trochus bicarinatus*, Lamk., has been expunged from the catalogue on the ground that only one example of the species is known, and that is probably a deformation of *Elenchus subincrassatus*. The genera *Gibbula* and *Turbo* are represented by one species each, and *Collonia* by two.

---

[1] Mém. Soc. Géol. France, 3^{e} ser. iii. (1884).

Neritopsis Lorioli, Cossm. and Lamb. is very properly transferred to *Nerita*; and *Neritina propinqua*, Cossm. and Lamb. is merged into *N. Duchasteli*, Desh., of which it is only the adult form. There are five species of *Odontostomia*; one, *O. Lamberti*, being new. Passing to the genus *Raulinia*, which both Fischer and Tryon have classed with the Littorinidæ, the author shows that it more properly finds a place in the Pyramidellidæ, close to *Odontostomia*, a conclusion arrived at from the study of the embryo. Two species of *Raulinia* are found near Étampes. Amongst the Pyramidellidæ, also, a new genus *Belonidium*, is proposed, of which the type is *Aciculina gracilis*, Desh.

The well known *Ampullina crassatina*, Lamk., is correctly referred to the genus *Megatylotus*, characterized, amongst other things, by an immense, broad, columellar callosity, sharply defined. The author seizes the opportunity to give the geographical distribution of this species. *Truncatella Bezanconi* is the name given to a new species discovered at Jeurre; we believe it is the sole representative of the genus in the Oligocene beds, although two species have been described from the Parisian Eocene.

Dealing next with *Hydrobia* we take objection to the figure and description, in a work devoted to Paris basin fossils, of a new Spanish species, *H. Rodillensis*, which is entirely out of place, even though it is incidentally alluded to in connection with *H. Dubuissoni*, Bouillet, a common form at Étampes. *Littorina obtusangula*, Sandb., a species occurring in the Mayence basin, has been added to the fauna under notice by the discovery of an unique specimen. Four species of *Lacuna* are found; one of them, *L. stilpna*, which is figured, was formerly referred in part to *L. striatula*, von Kœn., now said not to occur in the Étampes area.

The fact that Mr. R. B. Newton has shown that *Bayania semidecussata*, Lamk., is synonymous with the earlier *B. corrugata*, Lamk., seems to have escaped M. Cossmann's attention.

We cannot conclude our observations on this very valuable contribution to our knowledge of the Paris basin Oligocene mollusca, without expressing a regret that its learned author did not include in his revision the mollusca from the same horizon of other parts of the basin; they are not numerous and would have entailed but very little additional labour. The catalogue would then have been more comparable with his Eocene work. We may point out also that the title "marine" is not strictly correct as applied to the paper under review, seeing that several extra marine forms are described in it. It is a pity they were not all included, and the title suitably altered; but we are, perhaps, expecting too much. The work, so far as it goes, is most excellent. G. F. H.

CORRESPONDENCE.

Sir,—I have read with much interest the references made by Sir Henry H. Howorth to Glacial action in Iceland, in the course of his article in your July Number, pp. 302–309.

Having travelled through the country twice (1890 and 1891), mainly in quest of the summit of its highest peak, which was reached during the latter journey, I have had good and numerous opportunities of observing the peculiarities of its mountain structure.

On the whole, there can be no doubt as to the general result being decidedly in favour of Sir Henry's view. The instances he refers to are, however, of varying value. The gnarled points of such ridges as those of Almannagja can hardly be regarded as offering conclusive proof, since these are lava splits, and of too recent (geological) date to found an extensive inference upon; nor will Mr. Baring Gould's remarks as to the aqueous origin of apparently glacial striations apply to the marks which are plentiful at certain intermediate levels upon the mountains. These may be found, especially among the valleys leading to the Eastern fjörds, in positions too high above flood courses to permit of such an explanation. Nor will Mr. Watts' remarks as to the extension of the southern glaciers command universal acceptance now. On the other hand, however, it is of the utmost importance to notice that among the hard basalt masses of the east and south-east, the lower ridges up to the height of about 1000 to 1500 feet are often rounded, and striations are not uncommon; but above that height, at elevations which increase as one travels inland, these rounded hill-tops disappear, and sharp pinnacles form the rule. So sharp are these pinnacles that it takes a stranger some time to realize that they are not columns built upon the mountain summits. In point of fact each is the nucleus of the uppermost layer of the Trap beds, from which the rest of that bed has split away. Here is a far older and safer guide, telling of a time when many of these valleys, up to a certain level, had their glaciers; which, however, never formed part of an ice-cap to the island. So marked is the distinction between these peaks, rounded and pinnacled, that the conviction I have stated fairly forces itself upon one.

Further west along the south coast evidence of another kind is forthcoming from the volcanic masses which there replace the basalt of the south-east and north-west. So soft are many of the ridges that, on the hypothesis of a huge grinding ice-cap, they ought to have disappeared altogether. Yet there they remain, loose, shaly-laminated ridges, between which, in the valleys, lie enormous snow-fields with drainage glaciers coming down to sea-level now and overtopping lower hills, just as the most easterly ones used to do. On every hand signs abound, both of advance and of retreat, on the part of glaciers accommodating themselves to the inequalities of their beds, but none whatever of ice above a definite ascending level, nor of excavations beneath that level.

It is true large quantities of mud are brought down by such

Yrs sincerely

James W. Davis

rivers as the Jökulsá, but it would be strange if glaciers, twelve miles *wide*, did not produce such results by mere surface erosion. The wonder is they bring so little. But of this the probable explanation is the gentle fall—which I have ascertained to be about 100 feet per mile of progress in the case of the Breithamerkr—and the few uncovered ridges or peaks from which material may fall upon the ice.

FREDK. W. W. HOWELL.

10, HANDSWORTH WOOD ROAD, BIRMINGHAM,
July 14th, 1893.

OBITUARY.

JAMES WILLIAM DAVIS, F.L.S., F.G.S., F.S.A.

BORN APRIL 15, 1846. DIED JULY 21, 1893.

IT is with deep regret that we announce the death of Mr. James Wm. Davis, of Chevinedge, Halifax, at the comparatively early age of 47. A Yorkshireman of fine physique and robust constitution, endowed with apparently unlimited energy, the sad news of his loss has come as an unexpected shock to his large circle of friends both at home and abroad. His more intimate acquaintances were aware that a slight injury to a blood-vessel in the brain caused his retirement from active life for a few weeks last autumn; and they further learned with sorrow that a recurrence of the same malady last March necessitated a still longer period of rest at the little village of Grassington, in North Yorkshire. His letters, however, were cheerful, only marred by some feebleness in the handwriting, and when he returned to his seaside residence at Bridlington about the end of June, there were hopeful signs of speedy recovery. Mr. Davis' eagerness to fulfil his municipal duties at Halifax, however, led to an unwise visit to the town of which he was for the third time Mayor. The fatigue and unwonted excitement produced almost complete paralysis, and his wife, family, and friends had soon to mourn over his decease, which took place early in the morning of July 21st.

Descended from a Gloucestershire family, Mr. Davis was born at Leeds on April 15th, 1846. He was educated at the local Grammar School, and at an early age entered the cloth-dyeing business of his father. He and a brother soon became partners in the firm, which transferred its business to Greetland, near Halifax, and for the remainder of his life Mr. Davis took the leading share of its management. In 1876 he built his fine residence, Chevinedge, on a wooded ridge of Carboniferous Sandstone overlooking Greetland, and there are few geologists of note in Britain who have not enjoyed the hospitality of that modern English home.

Though deeply absorbed in his own business and in certain collateral undertakings—though taking a prominent position in every educational, municipal, and political movement in his own town and district, and elected Mayor of Halifax no less than three years in succession—Mr. Davis found time not only to become a well-known and valued patron of Art and Science, but also to rise to a high position as an investigator in Geology, Palæontology, and Archæology. Scientific work was, indeed, his solace and recreation. From his earliest boyhood, he was imbued with an ardent liking for the pursuit of Natural History; and in company with his friend and former neighbour, Mr. Percy Sladen, he was long occupied with practical work in Comparative Anatomy to enable him to carry on his future researches in interpreting fossil vertebrata. Only last winter, when Mr. Davis penned a long letter of woes to the writer of this notice, detailing how the whole of a new extension of his business premises had been burned down in one night, he concluded with the remark that all worries were just to be buried for two hours by the peaceful contemplation of *Acanthodes*—a Carboniferous fish on which he was writing a memoir for the Royal Dublin Society. Provided with what he termed a "prime Havana" and surrounded by piles of books and fossil fishes, Mr. Davis always found himself indeed in perfect peace and enjoyment.

From his earliest youth Mr. Davis had been connected with the Yorkshire Scientific Societies, and he first entered a wider sphere in 1873 by becoming a Fellow of the Geological Society of London and a member of the British Association. In 1875 he received the Fellowship of the Linnean Society, and also later that of the Society of Antiquaries. In 1891 he became a member of the Council of the Geological Society. Since 1876 he had been Honorary Secretary of the Geological and Polytechnic Society of the West Riding of Yorkshire, and brought the Proceedings, which he edited, to a high standard of value. In 1888 he organized the jubilee meeting of that Society, and subsequently wrote a volume detailing the history of its fifty years' work. He had occupied the Presidential chair of many local societies, was an active member of the Yorkshire Naturalists' Union, and an elected Governor of the Yorkshire College. He rarely missed the meetings of the British Association, where his keen business capacity was highly valued in the committees; and the circle of friends who had the privilege of being his guests at Chevinedge during the Leeds meeting in 1890, will never forget his qualities as a host on that occasion. In scientific journalism, too, Mr. Davis undertook no inconsiderable share of work. He was one of the directors of the "Westminster Review," and, if the London "Sun" can be trusted on a subject that has hitherto remained obscure, he was one of the promoters and chief supporters of Messrs. Macmillan's monthly, "Natural Science," a journal that has already attained a prominent position as a critical review of current matters in Geology and Biology.

In original research, as shown by the list of papers appended, Mr. Davis made many important contributions to knowledge of the Geology of Yorkshire; and in 1878, he co-operated with Mr. F. A. Lees, the Botanist, in a volume on "West Yorkshire: its Geology and Botany." He was also Secretary of the British Association Committee for the exploration of the Raygill Fissure, and took considerable part in many archæological investigations in the county, In Geology and Palæontology, however, Mr. Davis will longest be remembered by his numerous contributions to Fossil Ichthyology. The fish-remains discovered in the Yorkshire coal-field early attracted his attention and excited his interest; and after making the acquaintance of the late Earl of Enniskillen and Sir Philip Egerton at the Belfast Meeting of the British Association in 1874, he began the study of extinct fishes in earnest. He visited Florence Court and Oulton Park, where he was always a welcome guest, to study the great Enniskillen and Egerton Collections, subsequently acquired by the British Museum. He also travelled extensively abroad, and the present writer will always treasure the most pleasant recollections of several journeys in the company of Mr. Davis to the museums of Holland, Belgium, France, Germany, Austria, Hungary, Italy, Denmark, Sweden, and Russia. He made copious notes and drawings of fossil fishes in all these museums, and many of them were afterwards utilized in his publications. His first researches on the Carboniferous fish-remains soon extended to the fossils of later formations, notably those of the Lias and the Chalk; and since 1883 he had published a series of large memoirs in the Transactions of the Royal Dublin Society.

Mr. Davis' work in Fossil Ichthyology bears many indications of the difficulties under which it was produced. The investigations, it must be admitted, were not always thorough; and the results are not always so concisely and accurately expressed, with such evidence of a fulness of knowledge of the subject as a trained professional specialist would desire. We are happy to say, however, British science is still far from being under the control of a narrow professional monopoly, and long may this freedom remain. Mr. Davis has, even under the most difficult circumstances, been one of the largest contributors to our knowledge of fossil fishes during the last 20 years. His larger memoirs are exquisitely illustrated, as are also several of the smaller ones; and where he has fallen into errors he has done much for progress by rousing up other workers to correct them.

While investigating the fishes of the Yorkshire Coal-field, he made a very large collection in a more systematic manner than had previously been attempted; and Mr. Davis' writings contain more information concerning the remains of the sharks of the Coal-measures than is to be found elsewhere. His memoir on "The Fossil Fishes of the Carboniferous Limestone Series of Great Britain" (1883) is the only extended, illustrated account of the Elasmobranch teeth and spines of the Lower Carboniferous Rocks, and is based chiefly on the Enniskillen Collection. His subsequent memoir on the Cretaceous Fishes of the Lebanon contains a wealth of new matter, and marks a very valuable advance, notwithstanding all unfavourable criticisms that have been passed upon it. His further writings on the Cretaceo-Tertiary fishes of New Zealand and on the Cretaceous fishes of Scandinavia are pioneer monographs, dealing almost exclusively with untouched materials. Finally, Mr. Davis' latest work on the fish-remains of the British Coal-Measures, of which only one part has been issued, promised to bring together a great mass of material that had too long been neglected, and it is a distinct loss to Palæontology that the author's untimely end should have abruptly terminated the publication. We understand that the second part of this memoir, on the Acanthodians, is so near completion that it may be published posthumously.

A notice of the life and scientific work of Mr. Davis would, however, be very incomplete if we merely referred to his official responsibilities and his original researches. No one could come in contact with him for long without absorbing some slight proportion of his enthusiasm, his indomitable energy, and determination; and for at least 20 years he has probably had more influence than anyone else on the advance of scientific research in his native county. Many naturalists now occupying a conspicuous position in their respective lines of study owe their first kindly encouragement to him; many others have been incited to redoubled energy by personal intercourse with him. As the highly esteemed friend of most of the leading geologists both in Britain and on the adjoining Continent, and numbering in his large circle of acquaintances men distinguished in every sphere, Mr. Davis was a trusted adviser in many matters where only one with his great experience of the world could be of service. None, indeed, but those who have thus known him, can appreciate the loss which the scientific community has sustained by his decease.

Finally, we must add a word concerning Mr. Davis' liveliness of disposition, which kept him in the best of humour even in the midst of troubles and difficulties. Whether the worry were great or small, he could invariably lose all remembrance of it at will and apparently enjoy life as if nothing unfortunate had happened. The writer has a vivid recollection of being roused up in the middle of the night on one occasion at a remote railway station in Finland, when Mr. Davis was trying to explain to a clamorous crowd of officials that he had no ticket, but plenty of British paper money, which he would change at the end of the journey. After long discussion in a medley of languages, he induced the conductor to feel the weight of his "effects," which he suggested would be equal in value to the ticket, and the train was then allowed to proceed. Immediately afterwards, in the best of good humour, he pulled out from his portmanteau a small Swedish toy bought for one of his children, and playing with it, he remarked that it was well the inquisitive officer had not estimated the value by inspection. He resumed his slumbers, and as soon as an appropriate place was reached, borrowed from the same conductor enough Russian money to pay for breakfast. He never despaired, never regarded trouble too seriously—he was a friend whose companionship was truly cheering. A.S.W.

List of Memoirs and Papers by James William Davis, F.G.S.

1. Monthly analytical examination of the Harrogate Spas, 1872 [1873]. Pharmaceut. Journ. vol. iv. (1874), pp. 481, 482.
2. On a bone-bed in the Lower Coal-measures, with an enumeration of the Fish-remains of which it is principally composed. Quart. Journ. Geol. Soc. vol. xxxii. (1876), pp. 332–340.

3. The physical forces which have caused the present configuration of the Valley of the Calder in Yorkshire. Geological Magazine Dec. II. Vol. V. (1878), pp. 500–508.
4. On the Occurrence of certain Fish-remains in the Coal-measures, and the evidence they afford of their fresh-water origin. Brit. Assoc. Rep. (1878), p. 539; Proc. Yorkshire Geol. Soc. vol. vi. (1879), pp. 40–52.
5. Erratic Boulders in the Valley of the Calder [1875]. *Ibid.* vol. vi. (1879), pp. 93–100.
6. The Stems and Roots of Fossil Trees in the Lower Coal-measures at Wadsley, near Sheffield [1876]. *Ibid.* vol. vi. (1879), p. 79.
7. Unconformability of the Permian Limestone to the Red Rocks west of its Escarpment in Central Yorkshire [1877]. *Ibid.* vol. vi. (1879), pp. 280–308.
8. Notes on *Pleurodus affinis*, sp. ined., Agassiz, and description of three spines of Cestracionts from the Lower Coal-measures [1878]. Quart. Journ. Geol. Soc. vol. xxxv. (1879), pp. 181–187.
9. On *Ostracacanthus dilatatus*, gen. et sp. nov.: a Fossil Fish from the Coal-measures S.E. of Halifax, in Yorkshire. Brit. Assoc. Rep. (1879), p. 343; Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 191–195.
10. On the source of the Erratic Boulders in the Valley of the River Calder, Yorkshire. Geol. Mag. Dec. II. Vol. VI. (1879), pp. 313–321; Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 141–154.
11. Description of a New Species of Fossil Fish-spine, *Ctenacanthus minor*, from the Lower Coal-measures of Yorkshire. Geol. Mag. Dec. II. Vol. VI. (1879), pp. 531, 532.
12. On the Fish-remains found in the Cannel Coal, in the Middle Coal-measures of the West Riding of Yorkshire, with the Descriptions of some New Species [1879]. Quart. Journ. Geol. Soc. vol. xxxvi. (1880), pp. 56–67.
13. On the Teleostean Affinities of the Genus *Pleuracanthus*. Ann. Mag. Nat. Hist. ser. 5, vol. v. (1880), pp. 349–357.
14. On a new species of *Gyracanthus*, a Fossil Fish from the Coal-measures (*Gyrac. denticulatus*). *Ibid.* ser. 5, vol. vi. (1880), pp. 372, 373.
15. On the genus *Pleuracanthus*, Agass., including the genera *Orthacanthus*, Agass. and Goldf., *Diplodus*, Agass., and *Xenacanthus*, Beyr. Quart. Journ. Geol. Soc. vol. xxxvi. (1880), pp. 321–336.
16. On a Group of Erratic Boulders at Norber, near Clapham, in Yorkshire [1880]. Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 266–273.
17. On the Distribution of Fossil Fishes in the Yorkshire Coal-fields [1880]. *Ibid.* vol. vii. (1881), pp. 228–241; Proc. Geol. Assoc. vol. vi. (1881), pp. 359–370.
18. Report of the Raygill Fissure Exploration Committee [1880]. Proc. Yorkshire Geol Soc. vol. vii. (1881), pp. 300–305.
19. On the Exploration of a Fissure in the Mountain Limestone at Raygill. Brit. Assoc. Rep. (1881), pp. 645, 646.
20. On *Palæospinax priscus*, Egerton. Ann. Mag. Nat. Hist. vol. vii. ser. 5 (1881), pl. xx. pp. 429–432.
21. On the genera *Ctenoptychius*, Agassiz; *Ctenopetalus*, Agassiz; and *Harpacodus*, Agassiz. Ann. Mag. Nat. Hist. ser. 5, vol. viii. (1881), pp. 424–427.
22. Notes on the Fish-remains of the Bone-bed at Aust, near Bristol; with the Description of some New Genera and Species. Quart. Journ. Geol. Soc. vol. xxxvii. (1881), pp. 414–425.
23. On *Anodontacanthus*, a New Genus of Fossil Fishes from the Coal-measures; with descriptions of three new species [*A. acutus, obtusus, fastigiatus*]. *Ibid.* vol. xxxvii. (1881), pp. 427–429.
24. On the Fossil Fish-remains from the Armagh Limestone in the Collection of the Earl of Enniskillen. Proc. Geol. Soc. vol. xxxviii. (1882), pp. 12, 13.
25. On the Fossil Fishes of the Carboniferous Limestone Series of Great Britain [1882]. Trans. Roy. Dublin Soc. Sci. vol. i. (1883), pp. 327–600, plates xlii–lxv.
26. Notes on the Occurrence of Fossil Fish-remains in the Carboniferous Limestone Series of Yorkshire [1882]. Proc. Yorkshire Geol. Soc. vol. viii. (1884), pp. 39–63.
27. Description of a new species of *Ptycholepis* from the Lias of Lyme Regis. Ann. Mag. Nat. Hist. series 5, vol. xiii. (1884), pp. 335–337, pl. x.

28. Description of a new Genus of Fossil Fishes from the Lias. *Ibid.* series 5, vol. xiii. (1884), pp. 448–453, pl. xvi.
29. On some remains of Fossil Fishes from the Yoredale Series at Leyburn in Wensleydale. Geol. Mag. Dec. III. Vol. I. (1884), pp. 91, 92.
30. On some Sections exposed during the Formation of the Line of Railway between Upton and Kirk Smeaton [1882]. Proc. Yorkshire Geol. Soc. vol. viii. (1884), pp. 107–113.
31. On a New Species of *Heterolepidotus* from the Lias. *Ibid.* vol. viii. (1884), pp. 403–407, pl. xxii.
32. On the contortions of the Chalk at Flamborough Head. *Ibid.* vol. ix. (1885), pp. 43–49.
33. Note on *Chlamydoselachus anguineus*, Garman. *Ibid.* vol. ix. (1885), pp. 98–113, pl. xi.
34. On the relative age of the remains of Man in Yorkshire. *Ibid.* vol. ix. (1886), pp. 201–214.
35. On some remains of Fossil Trees in the Lower Coal-measures at Clayton, near Halifax. *Ibid.* vol. ix. (1886), pp. 253–256.
36. On the Exploration of the Raygill Fissure in Lothersdale. *Ibid.* vol. ix. (1886), pp. 280, 281.
37. On some Fish-remains from the Tertiary Strata of New Zealand. Geol. Mag. Dec. III. Vol. III. (1886), pp. 93, 94.
38. Notes on a Collection of Fossil Fish-remains from the Mountain Limestone of Derbyshire. *Ibid.* Vol. III. (1886), pp. 149–157.
39. The Fossil Fishes of the Chalk of Mount Lebanon, in Syria. Trans. Royal Dublin Soc. vol. iii. (ser. ii.) 1886, pp. 457–636, pls. xiv.–xxxviii.
40. On *Chondrosteus acipenseroides*, Ag. Quart. Journ. Geol. Soc. vol. xliii. (1887), pp. 605–616, pl. xxiii.
41. On the ancient Flint-users of Yorkshire. Proc. Yorkshire Geol. Soc. vol. ix. (1887), pp. 411–425.
42. Note on a Fossil Species of *Chlamydoselachus*. Geol. Mag. Dec. III. Vol. IV. (1887), pp. 392, 393 ; Proc. Zool. Soc. Lond. (1887), pp. 542–544.
43. Note on a Species of *Scymnus* from the Upper Tertiary Formation of New Zealand. Geol. Mag. Dec. III. Vol. V. (1888), pp. 315, 316.
44. On Fossil Fish-remains from the Tertiary and Cretaceo-Tertiary Formations of New Zealand. Trans. Royal Dublin Soc. ser. ii. vol. iv. (1888), pp. 1–48, pls. i.–vii.
45. History of the Yorkshire Geological and Polytechnic Society, 1837–1887. Proc. Yorkshire Geol. Soc. vol. x. (1889), pp. i.–ix., 1–479.
46. The Lake-Dwellings in East Yorkshire. *Ibid.* vol. xi. (1889), pp. 101–113.
47. Summary of Geological Literature relating to Yorkshire published during 1888. *Ibid.* vol. xi. pt. i. (1889), pp. 128, 129.
48. On the Fossil Fish of the Cretaceous Formations of Scandinavia. Trans. Roy. Dublin Soc. vol. iv. ser. ii. (1890), pp. 363–434, pls. xxxviii.–xlvi.
49. Fossil Fish-remains from Carboniferous Shales at Cultra, co. Down, Ireland. Proc. Yorkshire Geol. Soc. vol. xi. pt. ii. (1890), pp. 332–334.
50. Summary of Geological Literature relating to Yorkshire, published during 1889. *Ibid.* vol. i. pt. ii. (1890), p. 344.
51. On the Dentition of *Pleuroplax* (*Pleurodus*) A. S. Woodw. Ann. Mag. Nat. Hist. ser. 6, vol. v. (1890), pp. 291–294, pl. xiii.
52. On *Cœlacanthus Phillipsii*, Agassiz. Geol. Mag. Dec. III. Vol. VII. (1890), pp. 159–161.
53. On a New Species of *Coccodus* (*C. Lindströmi*, Davis). Quart. Journ. Geol. Soc. vol. xlvi. pp. 565–568, pl. xxii.
54. On the Discovery of a new Species of Fossil Fish (*Strepsodus Brockbanki*) in the Upper Coal Measures Limestone of Levenshulme, near Manchester. Mem. and Proc. Manchester Lit. and Phil. Soc. [4] vol. iv. 1891 (reprint paged 1–3). Geol. Mag. Dec. III. Vol. VIII. (1891), p. 465.
55. On some Sections in the Liassic and Oolitic Rocks of Yorkshire. Proc. Yorkshire Geol. Soc. vol. xii. part ii. (1892), pp. 170–214.
56. On the Fossil Fish-remains of the Coal Measures of the British Islands. Part i. *Pleuracanthidæ*. Trans. Royal Dublin Soc. Sci. [2] vol. iv. (1892), pp. 703–748, plates lxv–lxxiii. and Geol. Mag. Dec. III. Vol. X. (1893), pp. 72–75.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. X.

No. X.—OCTOBER, 1893.

ORIGINAL ARTICLES.

I.—Some Cretaceous Pycnodont Fishes.

1.—On *Athrodon.*

By Arthur Smith Woodward, F.L.S., F.G.S.

(PLATE XVI.)

It is well known that the crushing teeth of the Pycnodont fishes as a rule are arranged with striking regularity upon the bones which bear them, the vomer in the upper jaw and the splenials in the lower jaw. They are disposed in longitudinal series, gradually increasing in size backwards, and there is only one genus satisfactorily known (*Mesodon*) in which there is any marked tendency towards the frequent disturbance of this linear arrangement.

Thirteen years ago, however, Dr. Sauvage referred to the Pycnodonts some very robust splenial bones on which the teeth exhibited scarcely any regularity either in size or arrangement, and more specimens have subsequently been discovered which seem to justify his determination. For the fish to which these bones belonged, Dr. Sauvage proposed the generic name of *Athrodon*; and two species were described from the Portlandian and Kimmeridgian formations of the north of France.

That *Athrodon* does pertain to the family of Pycnodontidæ and is generically distinct from any of the satisfactorily determined forms may now be regarded as certain. So far as the present writer has been able to observe, the Pycnodonts never exhibit successional teeth; when the fish is young the teeth on the splenial and vomer vary little in size and are comparatively irregular; when the fish grows the bone extends and widens backwards, the series of teeth rapidly assuming their regular and distinctive characters. The splenial bone of *Athrodon* also exhibits no successional teeth, and it is thus apparently to be regarded as a genus of Pycnodonts, in which the initial irregularity of dental arrangement persists more or less throughout life. There is a tendency towards the differentiation of a principal longitudinal series of teeth in some species; and in a general way the number of series that would be present, if there were less irregularity, can be counted. The splenial bone, however, does not differ from that of other Pycnodonts merely in its dentition; it is more robust than in other genera, and the roughened symphysial facette is at least twice as deep as usual. In some specimens, indeed, the dentition is perhaps insufficient to determine whether they pertain to *Mesodon* or *Athrodon*, and in these cases the form of the symphysis must be relied upon. The teeth themselves are mostly smooth and rounded, sometimes in part mammillated.

If, as seems probable, the characters of the splenial dentition suffice to determine the species of *Athrodon*, seven forms are now known to the present writer. Besides the two French species Dr. Sauvage has already recognised the occurrence of a third in the Kimmeridgian of Hanover (*A. Wittei*); another has been described by Cornuel from the French Neocomian under the name of *Pycnodus profusidens*; one new species occurs in the Purbeckian, and another in the Cenomanian of England; and there is evidence of a third new species in the Senonian of Belgium. These may be enumerated as follows:—

1. Athrodon Douvillei, Sauvage.

Bull. Soc. Géol. France [3] vol. viii. 1880, p. 530, pl. xix. fig. 5.
Type. Left splenial bone; School of Mines, Paris.

The type species. Splenial bone longer than broad, with very small, widely spaced teeth, mostly circular and conspicuously mammillated, disposed in from 7 to 10 irregular series, somewhat enlarged towards the symphysial margin of the bone.

The dentition of the type specimen measures 0·019 in maximum width and 0·045 in length.

Form. and Loc.—Lower Portlandian; Boulogne.

2. Athrodon boloniensis, Sauvage.

Bull. Soc. Géol. France [3] vol. viii. 1880, p. 531, pl. xix. fig. 6.
Type. Right splenial bone; School of Mines, Paris.

Splenial bone comparatively elongated, with large, widely spaced teeth and few intercalated small teeth, mostly circular and conspicuously mammillated, disposed in about 4 to 6 series, scarcely enlarged towards the symphysial margin of the bone.

The dentition of the type specimen measures 0·027 in maximum width and 0·057 in length.

Form. and Loc.—Lower Kimmeridgian; Brecque-recque, Boulogne.

3. Athrodon Wittei, Fricke, sp.

H. E. Sauvage, Bull. Soc. Géol. France [3] vol. viii. 1880, p. 531.
Mesodon Wittei, K. Fricke, Palæontogr. vol. xxii. 1875, p. 364, pl. xix. fig. 15.
Type. Imperfect right splenial bone.

Splenial bone with small, widely spaced teeth, mostly circular and feebly mammillated, disposed in about 7 or 8 irregular series, of which that next to the innermost forms a relatively large principal series.

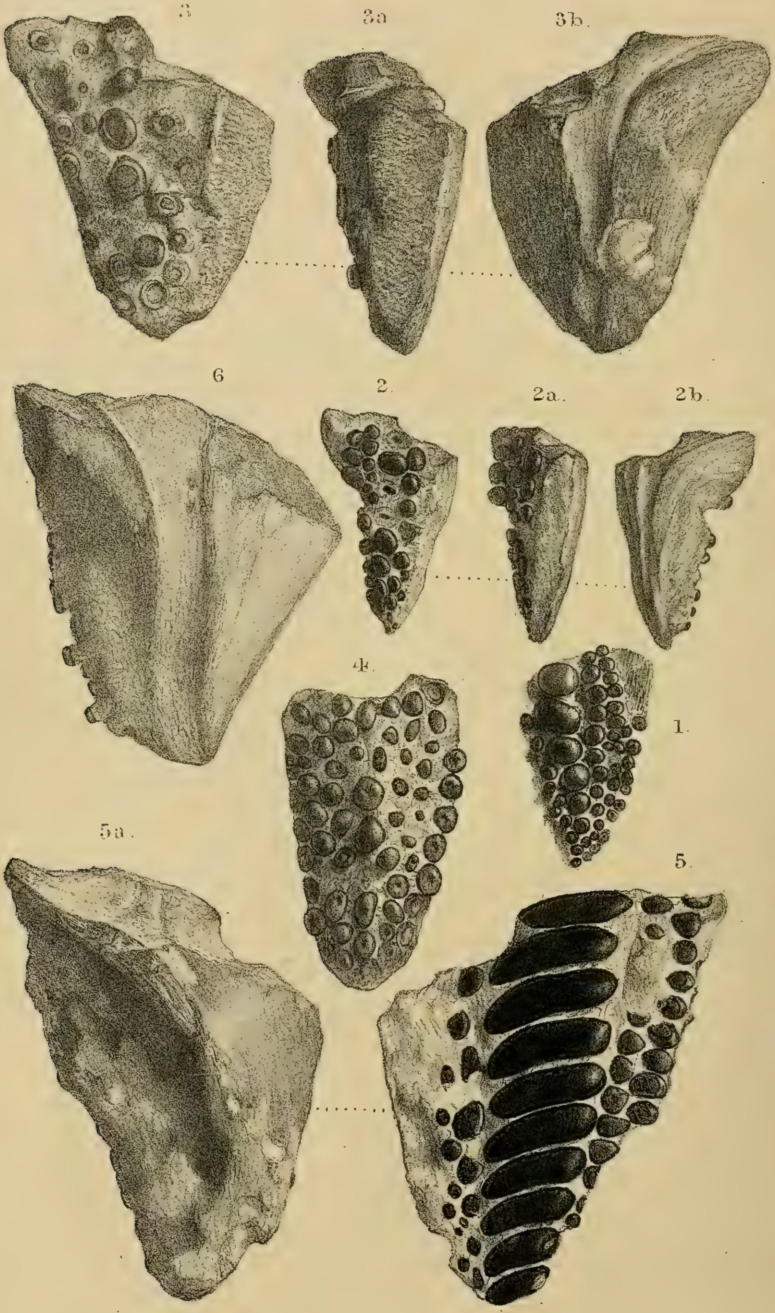
Form. and Loc.—Lower Kimmeridgian; Hanover,

4. Athrodon intermedius, sp. nov. Pl. XVI. Fig. 1.

Type. Left splenial dentition; British Museum (No. 40314).

Splenial bone comparatively elongated, with large, closely-arranged teeth, mostly smooth and nearly circular, a few exhibiting an apical pit with feebly crimped margin, disposed in about 5 or 6 irregular

Geol. Mag. 1893 Decade III. Vol. X. Pl. XVI.



F. H. Michael del. et lith.
Mintern Bros. imp.

CRETACEOUS PYCNODONTS.

series, the largest forming a principal series near the symphysial margin of the bone.

The dentition of the type specimen measures 0·017 in maximum width, and 0·03 in length.

Form. and Loc.—Purbeckian; Aylesbury, Buckinghamshire.

5. ATHRODON PROFUSIDENS, Cornuel, sp.

Pycnodus profusidens, J. Cornuel, Bull. Soc. Géol. France [3] vol. v. 1887, p. 609, pl. xi figs. 3–6.

Type. Splenial dentition.

Splenial bone short and broad with closely arranged teeth of moderate size, mostly smooth and circular, a few with a faint apical pit, disposed in about 7 irregular series, the largest near the symphysial margin of the bone.

Each splenial dentition in the type specimen measures 0·026 in maximum width and 0·059 in length.

Form and Loc.—Neocomian; Wassy, Haute Marne.

6. ATHRODON CRASSUS, sp. nov. Pl. XVI. Fig. 2.

Type. Right splenial bone with abraded dentition; Woodwardian Museum, Cambridge.

Splenial bone short and broad, with large, widely spaced teeth, mostly circular, disposed in about 4 irregular series, largest near the middle of the bone.

The dentition of the type specimen measures 0·02 in maximum width and 0·04 in length.

Form. and Loc.—Cambridge Greensand; Cambridge.

7. ATHRODON TENUIS, sp. nov. Pl. XVI. Fig. 3.

Type. Right splenial bone; Royal Museum of Natural History, Brussels.

Splenial bone elongated, with large closely arranged teeth, mostly smooth and nearly circular, disposed in about four irregular series, of which that next to the innermost is the largest.

The dentition of the type specimen measures 0 012 in maximum width and 0·027 in length.

Form and Loc.—Lower Senonian; Lonzée, near Gembloux, Belgium.

8. ATHRODON, sp. Pl. XVI. Fig. 4.

In addition to the foregoing it may be mentioned that the Woodwardian Museum, Cambridge, possesses an imperfect vomerine dentition from the Cambridge Greensand, which probably pertains to *Athrodon*, but appears to be too small for *A. crassus*. Nearly all the teeth seem to have exhibited an apical pit with crimped border, and their contour is mainly circular. The largest teeth occur in a discontinuous median row, and there is evidence of three irregular series on each side, not forming quite symmetrical pairs.

Probably many other examples of the dentition of this interesting Pycnodont genus exist in collections, and it is hoped that these brief notes may lead to their recognition. The writer would only add on the present occasion an expression of his indebtedness to Professor McKenny Hughes and MM. Dupont and Dollo for the opportunity of studying the specimens in the Museums of Cambridge and Brussels.

(To be continued in our next Number.)

II.—CONTRIBUTIONS TO THE GEOLOGY OF AFRICA.

By Miss CATHERINE A. RAISIN, B.Sc.

I.—ROCK SPECIMENS FROM UPPER EGYPT.

THE following notes have been drawn up from a study of specimens which were collected by G. F. Scott Elliot, Esq., during the earlier of two recent expeditions in Africa. He followed the Nile to somewhat beyond the second cataract, and brought back more than 130 examples of various rocks. The collection was sent to University College for examination, which I was allowed to undertake by the kindness of Professor Bonney, to whom I am further indebted for much help and advice on points of difficulty. A detailed description has been furnished to Mr. Scott Elliot to be included in the account of his journey, which it is to be hoped will be published before long. It may, however, be useful to have a short summary of the chief points of geological interest for general reference in an easily accessible publication.

A few illustrations of the well-known sandstones and limestones were brought from near Cairo, but with the exception of these (four in number) all the specimens were obtained from Upper Egypt, between latitude just north of 24° N. near the first cataract, and about latitude 21° 30′ N., south of Sarras, beyond the second cataract.

As many writers have now described, the sedimentary strata rest over a wide area in Egypt, Sinai and Palestine upon an old crystalline series.[1] While certain at least of these latter rocks are evidently igneous, others are described as presenting difficulties in field examination, and similarly, gradations from granite to gneiss can be traced in microscope slides. Thus, although a crystalline series of Archæan aspect doubtless occurs, traversed by ancient dykes and intrusions,[2] it is not easy, and in many cases not possible, to separate the hand specimens (even when illustrated by microscopic sections) into the two classes.

Normal granites are shewn in the well-known coarsely porphyritic variety from the Assouan quarry, and in several which have a binary character. In the more or less gneissoid rocks (of which some at least are probably Archæan) the foliation exhibits differences. In certain sections zones of mosaic undulate around lenticular, rather broken-looking, fragments with shaded border, the edge of the larger grains is cracked, and thin wavy laminæ of mica and hornblende sometimes traverse the slide. These characters have been often described and are doubtless due to subsequent pressure. Other examples shew a clear undisturbed intercrystallisation of the constituents, which are chiefly a quartz-felspar mosaic, large felspars (microcline or kaolinised plagioclase) and well formed biotite not streaked out in layers. The appearance of banding, and some elongation of the grains, may perhaps be attributed to a movement of the original magma, and the structure thus may be related to that which has been described from the districts of the Lizard and of Sark.[1]

---

[1] See description of specimens by Prof. T. G. Bonney, in GEOL. MAG. 1886, Dec. III. Vol. III. pp. 103–106; Prof. Dawson, GEOL. MAG. 1888, pp. 439, 440, 481, 482; K. A. von Zittel, "Ueber den geolog. Bau der libyschen Wuste," 1880, p. 9.

[2] See references above; and also 'Géol. de Palestine," M. L. Lartet, p. 55. I have to thank Mr. L. L. Belinfante, B.Sc., the Curator of the Geological Society, for kindly giving me facility to examine the collection brought by Mr. J. C. Hawkshaw, which was interesting for comparison, and included some similar types.

The diorites obtained from near Assouan have rather the character of intrusive masses, and may be connected with the dykes which have been described as cutting the basal series. From the second cataract, in addition to the felspar-hornblende rocks, which appear to be dykes, some well-marked clear diorites occur, possibly belonging to an old crystalline series, and the description suggests that they are parts of large masses, forming the typical rocks of the district. The hornblende in all appears secondary, affording illustrations of various modes of its development from augite. A crushed diabase was brought from south of Sarras and also a chlorite-schist.[2]

The specimens from undoubted dykes include basalt and micro-granite (Assouan), porphyrite (Kalabsheh) and other varieties. One point of interest is the fairly large number of rocks from near Assouan which are connected with the mica-trap group [35, 36, 26]. They vary from somewhat micaceous diorites to well-developed kersantites; they have often an orientation in the mica, and lead up to specimens which are really mica-schists in appearance. It is interesting to have further illustrations of this group of not very common igneous rocks, which had already been shown by Professor Bonney to exist in the district, in his description of specimens brought by Sir W. Dawson.[3]

A schistose character is also found in certain hornblende rocks which are described as dykes [32, 34]. They are certainly igneous, and consist of plagioclase felspar and green dichroic hornblende.[4] The absence of pressure effects and the appearance of quiet crystallization suggests that the foliation again here may be a fluxional structure. A dyke from Elephantine [33] is a rather exceptional rock, of a dull red colour, the slide consisting of plagioclase felspar, of a brown, probably ferriferous hornblende, allied to arfvedsonite, of pale violet-coloured augite and dense interfelted granular masses, including an acicular mineral (? a zeolite) and analcime. If these patches replace original crystals, their outlines are not now distinguishable, but the aggregates very possibly resulted rather from alteration of a ground-mass filling up interspaces. The rock bears some resemblance to the augite syenite described by Brögger from Norway; although the presence of nepheline or elæolite cannot be proved,[1] and, as stated just previously, the mass very probably was not even holocrystalline, but possessed an andesitic matrix. The augite has definite outlines, and probably was formed early, and hornblende was developed partly by conversion of the augite, partly as a zone surrounding it.

---

[1] Q.J.G.S. 1891, vol. xlvii. p. 497, Prof. Bonney and Major-Gen. McMahon on the Crystalline Rocks of the Lizard District. Q.J.G.S. 1892, vol. xlviii. pp. 132–138, Rev. E. Hill and Prof. Bonney, on the Hornblende Schists of Sark.

[2] This specimen may possibly be related to a chlorite-schist which has been described from the borders of Abyssinia.

[3] Geol. Mag. 1886, p. 106.

[4] The hornblende is in clear rounded grains in one slide, which also contains a light-coloured augite similar to a variety shown to me in a Hebridean diorite by Prof. Bonney. Another of the hornblende-felspar rocks, as Prof. Bonney also pointed out, bears some resemblance to a foliated diorite in Guernsey.

Certain syenitic or granitic rocks from near the second cataract appear from the description to be intrusive in the diorite, and the evidence from some junction specimens, although not decisive in single examples, is in favour of this view. [113.] In one, the granite is coarsely crystalline, but the diorite forms a small piece, which probably has been included in the heart of the intruding mass. In the fragment, greenish hornblende is in the form of aggregates of small crystals confusedly orientated, enclosing in a few cases a partially decomposed core of augite. But in addition to characters which are common in a hornblende-diabase or uralite, a further alteration can be traced. Small crystals of clear brown mica form a zone along the border of the original pyroxene. These range roughly parallel to the boundary, or they project outwards penetrating the adjacent felspar; sometimes a small group occurs surrounded by felspar (Fig. 1). Thus, as Prof. Bonney has suggested in connection with a specimen from Sark, the mica seems to have crystallized at the expense of the felspar and the pyroxene.[2] This secondary development possibly may be due to the influence of the intruding granite, for it is the kind of change which we generally associate with contact metamorphism, and we note here that the mica films are smaller than the size of the felspar and pyroxene would lead us to expect (see Fig. 1, p. 442).

[87.] The diorite in another contact specimen also shows peculiar alterations. Dull green or brown dichroic crystals, partly of hornblende, partly of brown mica, are scattered with a rough orientation within a mass of plagioclase felspar. The felspar is generally idiomorphic and has a sharp demarcation between a kaolinised interior and a clear external zone (Fig. 2). The intrusive rock is a reddish felstone; it consists mainly of a micrographic mass surrounding and often growing from rectangular cores of dusty felspar, which themselves are sometimes zoned. If we may infer, as has been pointed out by Professor Bonney in the "syenite" of Charnwood,[3] that for the formation of this micrographic structure the rock mass was kept for a long time at a low temperature, the peculiar character of the diorite may have resulted from the "stewing" undergone, and so may possibly be a kind of contact metamorphism.

---

[1] The interfelted mass bears some resemblance to that in a nepheline syenite from Montreal, shown to me by Prof. Bonney.

[2] Q. J. G. S. 1892, vol. xlviii. p. 131, fig. 3.

[3] Q. J. G. S. 1891, vol. xlvii. p. 105. On a Contact-structure in the Syenite of Bradgate Park, by Prof. T. G. Bonney.

One specimen of an andesite—a pale peach-coloured rock—contains fairly large fragments, among which clear glassy quartz is conspicuous. The microscope shows that these included parts are a foreign element (quartz and felspar) evidently belonging to a rather coarse granite or granitoid rock. They vary in size, from ¼ inch to small microscopic pieces. The edges, sometimes straight along cleavage boundaries of the felspar, seem sharp, and show no evidence of melting down, unless a narrow border with lighter streaks indicates such an effect. The ground-mass is evidently glassy, exhibiting fluidal structure, and it seems to represent an andesitic magma, which has broken through and enclosed fragments of a granite or gneiss.

Specimens of rocks collected from near the base of the overlying sandstones at Abu Seir and at Kormoon are very rotten, but appear to be much decomposed basalts or dolerites, now consisting mainly of a ferruginous mass with a pinite-like mineral. They might represent old lavas which flowed above the massive igneous series; but they more probably are dykes intrusive in the underlying rocks or more or less along the junction plane.

Among the lower crystalline rocks the signs of deformation are not very marked, although on some specimens the great earth-movements or local disturbances have left their impress. Thus a much crushed and consolidated diabase occurs at more than one place;[1] some gneisses of Assouan show structures due probably to pressure of ancient date, and some other illustrations can be found; but on the whole the disturbance is certainly not extreme.

The overlying sedimentary rocks appear to be almost horizontal and undisturbed. They are in nearly all cases sandstones of the Nubian type and consist mainly of quartz and felspar (often microcline) frequently forming a true arkose. Thus they were evidently derived from the disintegration of the lower crystalline rocks.

Sands cemented by iron oxide form a kind of 'pan' such as has been noticed in previous explorations.[2] This character often appears to be associated with a hot, dry climate and a short but heavy rainfall on a sandy country. The accretion of secondary quartz pyramids is also illustrated,[3] and the grains are rounded and angular, including probably a mixture of materials transported by wind and by water. The drifting of desert sand would doubtless smooth rock-surfaces, and some beautifully polished specimens have been brought from the Nile Valley. The glaze[4] may indeed have been added to by deposition from water, but below the level of High Nile, whence most of the specimens were obtained, we note in photographs taken by Mr. Scott Elliot that sand is piled up abundantly around the hard rocks. Also the streaked and furrowed surface resembles sand-polished rocks from elsewhere.

---

[1] One specimen is from far south beyond Sarras; others from further north near Wady Halfa.

[2] Mineralog. and Petrogr. Mittheil. G. Tschermak. 1886, vol. viii. p. 24; Across East African Glaciers, Dr. H. Meyer, p. 347.

[3] See J. A Phillips, Q.J.G.S. 1881, vol. xxxvii. pl. ii. figs. 1, 2, 3, 5.

[4] See M. L. Lartet, Géol. de Palestine, p. 57; similar specimens are described by J. C. Hawkshaw, Q.J.G.S., vol. xxiii. p. 116.

From these specimens we can make only a few general inferences —and those not entirely new—as to the order of succession. It seems probable that granite and gneiss near the first cataract, and diorite near the second, form a fundamental crystalline series. At some later epoch or epochs, igneous irruptions occurred of acid, intermediate, and basic rocks. Among these are the numerous mica-traps, or mica-diorites from near Assouan. Near Wady Halfa felstone and granite seem to cut the diorite, while an andesite is perhaps still later cutting the granite. Basic magmas subsequently were intruded as dykes, or possibly were poured out as lavas. The disturbed period marked by igneous action was followed by denudation of the lower crystalline rocks and the tranquil deposition of the overlying sandstones and arkose.

The specimens which have been examined may be arranged roughly in the following classes, the order of succession in certain cases being somewhat hypothetical :—

1. Crystalline rocks, probably fundamental; granite, gneiss, diorite.
2. Igneous rocks, probably intrusive.
    (*a*) Near the first cataract: microgranite, basalt, porphyrite, augite-syenite (?), mica-trap, diabase.
    (*b*) Near the second cataract:
        (1) Intrusive in diorite, granite or syenite: microgranite, felstone.
        (2) Intrusive in granite: andesite.
        (3) Basalt or dolerite (lava flow or intrusive).
3. Sandstones and arkose.

II.—Specimens from West Africa (Sierra Leone).

In a second African expedition, starting from the west coast, Mr. Scott Elliot collected about a hundred rock specimens, which also have been examined at University College under the supervision of Professor Bonney. A detailed account has been furnished to Mr. Scott Elliot, and is published in the Colonial Report on Sierra Leone,[1] but a short summary of the results may be of interest.

The foliated rocks, of which many are certainly igneous, doubtless belong to an ancient series. They include gneiss, and foliated granite, sometimes containing hornblende or biotite. But few specimens appear to have been severely crushed. The igneous rocks, other than granite, are doubtless, in some cases, dykes or sills and intrusive masses, but many examples equally well might be parts of lava flows, a question to be decided only by field examination. Petrologically they are mainly dolerites, often interesting from the presence of olivine, enstatite or hypersthene. A tendency to a spherulitic structure is shewn in one specimen, which is a compact rock, probably from near the edge of an enstatite-dolerite mass.

---

[1] Colonial Reports. Miscellaneous, No. 3, Sierra Leone. Reports on Botany and Geology, 1893. I regret that, as I unfortunately missed seeing the proof of this paper, some printers' errors in it have escaped correction.

The sedimentary rocks seem to belong to at least two periods. Some strong grits and conglomerate, lithologically resembling the Welsh Cambrian or Scotch Torridonian, are probably of old Palæozoic, or even earlier age. Differing from these are quartz-sandstones, sometimes ferruginous, which are very similar to the Nubian sandstones. Various argillites, mudstones, and muddy quartz-felspar grits are found, some exhibiting slight results of contact alteration, due, very possibly, to the adjacent dolerites.

In the first part of the journey from near Kambia, along the Scarcies River, gneissose rocks were exposed, and at Sasseni the ancient grit, derived partly at least from old Archæan schists, and resembling, as previously stated, some early conglomerates of our own island.

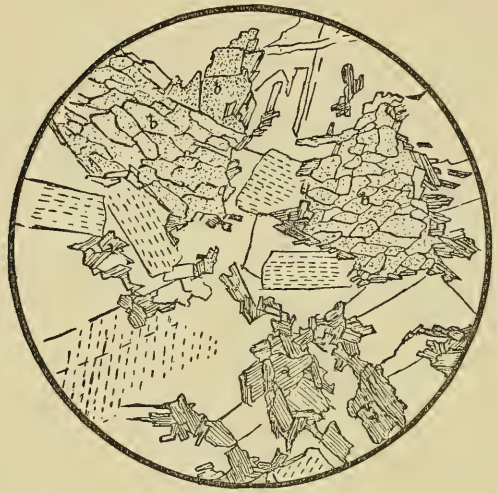
The Kofiu Mountain rising to a height of 3200 feet seems to be mainly formed of gneiss, probably Archæan, capped by "undisturbed horizontal sandstones" of a Nubian type "800 feet thick." Along the upper part of the Scarcies River in Mount Jambi Buyabuya. are compact diabase, ophitic dolerite, olivine dolerite, and some sedimentary rocks. In the Talla Plateau (2000 to 3500 feet, about lat. 10° N.) igneous rocks of a basic type seem to be well developed. Dolerite apparently forms the top of the plateau for 20 or 30 miles, ending at one place in "an abrupt cliff 400 feet high." The summit of the Gonkwi Mountain (altitude 3000 feet) consists of an enstatite-dolerite with one partly spherulitic specimen; and associated with this mass and other igneous rock are argillites and gritty mudstones, some showing slight contact alteration. Near Kundita and Falaba (altitude 3500 feet, about lat. 10° N.) micaceous gneiss is common, and here also a hyperstheneiferous diorite or norite occurs, containing amblystegite.

On the return journey to the coast at a point further south near Sierra Leone, some crushed specimens of schist and a mylonite, and some igneous rocks of basic or somewhat basic composition were collected. One dolerite has become a richly ferruginous and probably workable ore by the formation of iron oxide apparently replacing a pyroxene, the felspar having been replaced by a pinite-like mineral. Iron oxide frequently also is deposited in the usual way in sandstone, often forming an "iron pan" or "laterite."

Thus we find a general resemblance in many points between the rocks collected towards the extreme east and west of the African continent.[1] Above the foundation stones of gneiss and similar crystalline rock, rest the sedimentary deposits which (except the probably more ancient conglomerate and grit) seem mainly to be of the uniform Nubian type. The associated igneous rocks, whether they are intrusions or lava flows, are often lithologically similar in both districts.

[1] See also Phil. Trans. 1883, On a Collection of Rock Specimens from the Island of Socotra, Prof. T. G. Bonney. Also Geol. Mag. 1888, Dec. III. Vol. V. p. 414, C. A. Raisin, On some Rock-specimens from Somali Land; p. 504, On some Rock-specimens from Socotra.

FIGURE 1.



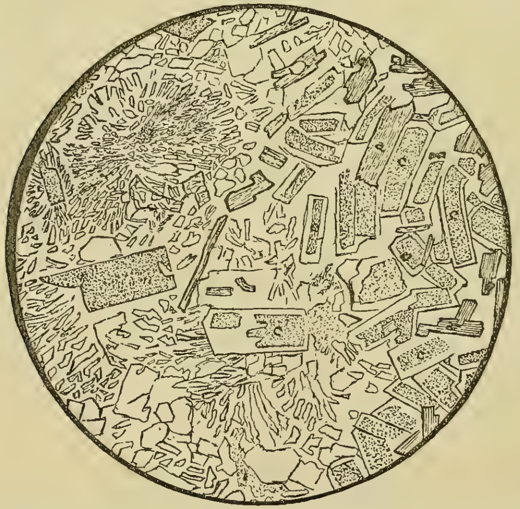
Microscopic section from a small (two-inch) fragment of diorite which apparently was included within a fairly coarse granite. From Wady Halfa [113].

In the diorite, small crystals of biotite, which occur in connection with the hornblende, and imbedded in the felspar, appear to be secondary, and very possibly originated as results of the contact alteration. (Compare Q. J. G. S. 1892, vol. xlviii. p. 131, fig. 3.) See p. 438.

a. Biotite. *b*. Hornblende probably derived from an original pyroxene.

The remainder of the slide is occupied by felspar, the part marked by broken lines showing plagioclase twinning. (Magnified about 35 diameters.)

FIGURE 2.



Felstone intrusive in diorite. From near second cataract of the Nile [87]. The mciroscopic slide shews the junction of the two rocks, omitting towards the upper part some of the intervening mass in order to bring more complete illustrations of both specimens within a small diagram. The felstone (on the *left* of the figure) exhibits micrographic structure sometimes developed around nuclei of kaolinised felspar. The diorite (on the *right* of the figure) shows a greenish altered mineral, and felspar crystals in which a clear zone surrounds a kaolinised interior (see p. 438).

a. Greenish mineral, partly biotite, partly hornblende.
c. Felspar crystals with kaolinised interior.
Iron oxide, only some of which is shown.
(Magnified about 30 diameters.)

III.—The Upper Devonian Fishes of Ohio.

By Prof. E. W. Claypole, B.A., D.Sc. (Lond.), Buchtel College, Akron, Ohio, U.S.A.

Under the true Carboniferous strata of Ohio, that is below the base of the Berea Grit, lies a mass of shale of varying colour many hundred feet in thickness. The uppermost fifty or sixty feet are often red or reddish, and have been separated with the name of the Bedford Shale. The next layer, of about the same thickness, is usually black or at least very dark and bears the name of the Cleveland Shale. Below this again is a greenish mass 500 feet or more in thickness, known as the Erie Shale. Another dark bed follows—the Huron Shale—beneath which is the great limestone base of the Devonian in Ohio, the Corniferous.

The Upper part of this great shaly mass has been variously classed with the Carboniferous and the Devonian, according to the knowledge and the opinions of the writers. It is most accordant with fact to regard it as the representative of a period of transition between these two eras, inasmuch as there is no physical break to be detected generally in the field, and, as will presently be shown, no line can be drawn in the palæontological record. We have here, as in some other places, an uninterrupted series of strata filling the interval between the two series, and were the palæontological record as full as the stratigraphical, important connecting links would doubtless be discovered.

But unfortunately the story of life is very incomplete. The shales are usually barren. The Red Bedford has yielded few traces of life except in its lowest bed, and even there they are not abundant. Still the few Brachiopods that have been found imply strong Carboniferous affinity. Some of them are:—

Syringothyris typus, Win.
Orthis Michelini, Lev.
Spiriferina solidirostris, White.
Macrodon Hamiltoniæ, Hall.
Chonetes Logani, Hall.
Lingula Cuyahoga, Hall.

The Black Cleveland Shale next below, with which this paper will chiefly deal, was for many years a barren ground to palæontologists. Nothing at all had been found in it; but recently and locally it has proved to be a rich storehouse of fossil fishes of new and strange types. But these are all, except now and then, a fragment of fossil weed (Dadoxylon) or more rarely still a broken and crushed molluscan shell such as *Eodon bellistriatus* or a closely allied form.

From this shale have come almost all the known species of

Dinichthys, all those of *Titantichthys*, and the single specimen of *Gorgonichthys* yet found (see American Geologist for 1892). These monsters paralleled in form and size those which tenanted the seas of Europe in the late Devonian days, and with some of which the name of Hugh Miller is inseparably connected.

All these, by name at least, are now familiar to the palæontologist chiefly through the classic writings of Dr. Newberry. But since his time further research has brought to light a new fish fauna from these shales of equal interest but of very different nature.

For some years a few scattered Cladodont teeth have been known from the shales of Ohio. Five species in all were given by Dr. Newberry in his contribution to the Palæontology of Ohio (vol. ii. p. 46, etc.). These are:—

C. subulatus, Nby., Cuyahoga Shale.
C. concinnus, Nby., Cleveland Shale.
C. Hertzeri, Nby., Bedford Shale.
C. parvulus, Nby., Cleveland Shale.
C. Pattersoni, Nby., Berea Shale.

Of these the first and last belong above the Berea Grit in undoubted Carboniferous territory and need not be further noticed. The other three constitute all our knowledge of the Cladodonts of Ohio from rocks older than the Berea Grit until quite lately.

Nor was anything more known of this family in the Old World. The European Devonians, with all their wealth of fish fossils, are almost as poor in the evidence which they afford us of the existence of Sharks as the coeval strata in America, while of the Cladodonts in particular they tell us almost nothing.

And when we turn and ask what we really know of these fishes from other and later strata we find our ignorance oppressive. Teeth of Cladodonts abound in the Carboniferous rocks, and spines, supposed rightly or wrongly to belong to them, are also not scarce. But of the fish themselves that bore these weapons, we knew a few years ago absolutely nothing.

The first glimpse which we obtained of the body of a Cladodont Shark was that of a broken and incomplete relic, described by Dr. Traquair in the GEOLOGICAL MAGAZINE for February, 1888. Only the fore part of the fish was there. It had been pieced together, and some doubt existed if all the fragments belonged to the same specimen. A part of the head, with true Cladodont teeth, a fin, and a mass of "crushed and inextricably confused cartilages," formed the unpromising material from which it was the task of the palæontologist to try to restore to order. It gave us a glimpse and nothing more.

In the following year appeared Dr. Newberry's great "Monograph of the Fossil Fishes of North America," in which he, for the first time, figured nearly the whole of a *Cladodus* from the Black Shale, under the name of *Cladodus Kepleri*, and a second, less complete, as *C. Fyleri*. Here we had for the first time an opportunity of forming an approximately adequate conception of the size and shape of these ancient sharks. But the specimens at Dr. Newberry's command were not good enough for full and exact specific description.

It is a little surprising that at last the material for enabling us further to realize our picture should have come from these long-called barren shales of Ohio. But during the past two years an enthusiastic and patient collector, Dr. Clark, has brought to light a number of specimens in a wonderfully good condition considering the pyritized state of all the fossils from this stratum. By dint of great labour he has so far cleared them from the matrix that I have been able to describe at least five species in addition to the one figured by Dr. Newberry. The details may be found in the American Geologist for May, 1893. It is not my intention here to dwell upon the specific distinctions of these fishes, but to point out a few interesting facts and inferences in the palæontological history of the Cladodonts.

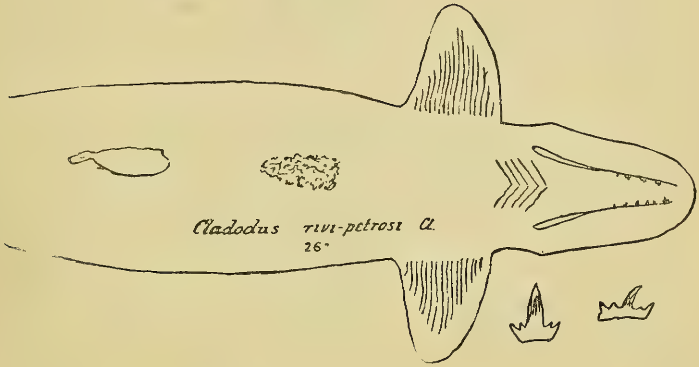


Fig. 1.—Head, pectoral fins, and abdominal region of *Cladodus rivi-petrosi*, Claypole; with two teeth enlarged.

The figures given herewith will enable the reader to form some idea of their general shape, at least as they are preserved in the fossils. All the specimens yet discovered present either the dorsal or the ventral aspect, in almost all cases the latter. The Shark apparently settled down in that position on dying, perhaps owing to the accumulation of gases in the abdominal region.

The most obvious unusual feature is the expansion of the head. This is so much wider than the body that the fish appears to have a neck in some cases, as in *C. sinuatus*, etc. In others the constriction is less, while in some it is almost absent. The suspicion is of course aroused that it may be a result of something in the process of fossilization, but an examination of the specimens renders this unlikely. It is not, apparently, due to pressure or distortion.

Among existing Sharks it is not easy to find any structure that when fossilized would show a similar form. But the Bonnet Shark, or the Shovel-nosed Shark (*Reniceps tiburo*), may be quoted as an illustration of a fish that in outline, as seen from above, might produce an impression resembling the one in question. On a side view this shark shows the ordinary inferior mouth and sharp snout of the family. But its head is extended laterally into a thin, sharp-edged flange, on the margin of which are set the eyes. This flange suddenly terminates backwards, its edge turning in at right angles to the axis of the body. Its dorsal aspect consequently presents a head twice as wide as the body and semicircular in outline at the front. Such a form may without much effort of the imagination be compared with that of the Cladodonts (see Fig. 1).

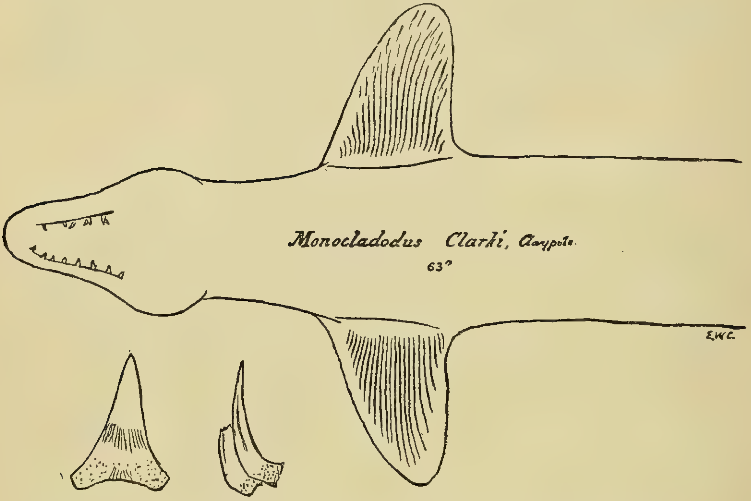


Fig. 2.—Head, pectoral fins, and abdominal region of *Monocladodus Clarki*, Claypole; with teeth enlarged.

A yet more singular expansion of the head occurs in the Hammer Shark. But the great lateral extent in this fish is less suggestive of the head of these Cladodonts than is that of the Bonnet Shark.

It is not my intention here to imply that any close affinity existed between this fish and the ancient Cladodonts. This may or may not have been the case. Animals far asunder in our system frequently simulate one another's form, so that no argument can be drawn from mere external similarity. The condition of these pyritized fossils prevents for the present any detailed study of their structure.

In one or two species there is a remarkable expansion of the skin or some membrane as a horizontal flap just in front of the caudal fin. I know no analogy that exactly meets this structure. Nor can I assign a use for this organ. In one or two specimens it is exceedingly well-preserved. In other species it may have been absent, or is concealed or destroyed. The tail and adjacent parts are frequently in bad condition. The flap shows no rays or markings of any kind. It was not covered with shagreen and was evidently quite soft. It seems to have no analogy with the flattening of the body that is characteristic of the skates and rays.

So far as it is possible to determine from the specimens thus far found, no spines were present anywhere on the fish. On this point the position of the fossils leaves little room for doubt. In view of the identity that has been suspected between the Cladodonts and Ctenacanthus this point is of considerable interest. The dorsal fins are not clearly shown even in those specimens which are lying on their ventral faces, but it is scarcely possible to believe that had a spine in any degree resembling *Ctenacanthus* been present its mark or its cast must somewhere have been visible. Dr. Traquair evidently inclines to this view. In the GEOLOGICAL MAGAZINE for February, 1888, he says, "No spine is visible on the East Kilbride *Cladodus* but the body is mostly absent." "In the Eskdale *Ctenacanthus*, though I interpreted its one imperfect tooth as Cladodont, I am willing to leave that an open question." "The teeth found associated with *Ctenacanthus hybodoides* are allied to *Hybodus*. It has nothing to do with *Cladodus*."

In addition to all this the evidence of the Ohio specimens seems conclusive that *Cladodus* was a spineless Shark, whether closely allied to *Chlamydoselachus* or not. The spines, therefore, that occur in the Devonian rocks must be assigned to some other fish. *Ct. vetustus* of the Cleveland Shale and *Ct. Wrighti* of the Hamilton remain unappropriated.

Another point worthy of notice is the skin of these Cladodonts. This on the dorsal surface shows no difference from ordinary shagreen. The minute dermal ossicles are smooth, showing in most cases little or no sign of sculpture, though occasionally traces of a pattern may be seen; but on the ventral surface this shagreen is absent, and thin rhomboidal scales supply its place, reminding one very much of ganoid plates of great tenuity. These are arranged in diagonal lines across the lower surface, exactly as are those of a Gar or other ganoid fish. Dr. Newberry has indicated this character in his figure, and it is much more evident in some of the recently found specimens: apparently it is common to them all.

In regard to the pectoral fins, the evidence is obscure in spite of the apparently excellent state of preservation. There is no trace of a median axis or of two rows of rays. The fin is consequently not archipterygial in type, and the Cladodonts, therefore, if retained among the *Ichthyotomi* must be considered abnormal. Only a single row of fin-rays is present and the basal cartilages on which they are set are concealed in the pyritous mass to which the body in general is reduced. The full description of the fins must therefore await the results of future discoveries.

The position taken at the outset that the Cleveland Shale is intermediate between the true Carboniferous rocks above and the true Devonian below will be justified when we consider the strange assemblage of fishes whose remains have come to light from this stratum. The great Placoderms, *Dinichthys, Titanichthys* and *Gorgonichthys* are essentially Devonian in type, and are the analogues of the armoured fishes of the Old Red Sandstone of Scotland and of other parts of Europe. On the other hand, the Cladodonts are almost as essentially Carboniferous in aspect, or at least have hitherto been so considered. The presence of *Coccosteus*, it is true, gives an air of antiquity to the fauna by its strong Devonian affinity. It is, however, in Ireland and Canada an Upper Devonian genus. On the other hand, a small ganoid seen in a macerated condition in the stomach of the Cladodont *C. rivi-petrosi*, and shown in our Figure, though incapable of exact interpretation, suggests *Palæoniscus*.

Beyond question we have in this shale a stratum which records a transition time. The canons of palæontology must be very freely interpreted to allow of such a confusion of species. But this is only what we look for with advancing knowledge. All the hard and fast lines between our little systems must be blotted out, and the record of life becomes one continuous story before the tale of the rocks is fully told.

It is scarcely too much to assume that in the Cleveland Shale we shall have preserved for us in its hard, tough concretions the history of a quiet time and a quiet area, where the Devonian fishes lived on and the Carboniferous forms developed by their side. The Cladodonts no longer burst upon us in full splendour with the Mountain Limestone, but we find them abundant long ages before the time of its deposition, living side by side with *Coccosteus*. To discover their origin and their ancestors we must go further back and seek their remains in lower and older strata.

General Section in N.E. Ohio.

		Feet.
Carboniferous	Carboniferous Conglomerate (Millstone Grit)	250
	Lower Carboniferous Limestone (Mountain Limestone)	0
	Logan Group	0
	Cuyahoga Shale	250
	Berea Shale	20
	Berea Grit	50
	Bedford Shale (often red)	50
	Cleveland Shale (dark or black)	60–20
Devonian	Erie Shale (greenish)	3000–0
	Huron Shale	not cropping out at surface.
	Hamilton Shale	
	Corniferous Limestone	

IV.—On the Origin of the Engadine Lakes.

By C. S. Du Riche Preller, M.A., Ph.D., Assoc.M.I.C.E., F.C.S., F.G.S.

ANY geologist who, in these days, is still bold enough to affirm that the origin of Alpine Lakes generally is due to glacial erosion, must surely derive considerable comfort from a visit to the Upper Engadine; for the four lakes which adorn that valley appear, at first sight, to constitute so many typical examples of the erosive power of the ancient Inn glacier, and therefore a striking confirmation of that time-honoured theory. A closer and more extensive examination of the physiography of that exceedingly interesting district, leads, however, as in so many similar cases, to a very different, and precisely opposite conclusion.

In following the gently ascending Upper Engadine Valley from Samaden, situated below the outflow of the river Inn from the last, viz. the St. Moritz Lake, the valley at the Upper or Maloja end seems to be closed in by an imposing chain of mountains in which that river may naturally be supposed to rise. But the peculiar feature of the district consists precisely in this, that what above the uppermost, viz. the Sils Lake is locally, and also in text-books, termed the "Inn," is a mere insignificant stream which rises only about a mile higher up, in the small lake of Lunghino, situated at an altitude of 2408 metres, 1900 feet above sea-level, or about 2000 feet above the Sils Lake. This is at first the more puzzling, because the locality of Maloja forms an alluvial plain which is evidently the remains of a former river bed of considerable extension. The fact is that there really exists now no individual river Inn as feeder of the four lakes, and that the Inn of the present day, as known in the Lower Engadine, only begins at Samaden after its confluence with the Bernina, and *per se*, is nothing but an agglomeration of Alpine torrent falling into the lakes between that village and Maloja. The sources of the ancient river Inn which was powerful enough to erode and form the Engadine valley, only become apparent when we go beyond, viz. south of Maloja. As is known to every one who is familiar with the district, the Plain of Maloja is a depression between two parallel mountain ranges trending S.W. to N.E., which divides the present watersheds of the Inn and Meira systems, and forms the summit of the Pass of the Alpine route from Chiavenna to the Engadine. Immediately after Maloja, the ground takes a sudden plunge of 250 metres or of about 800 feet at an angle of 45 degrees into the so-called Bargaglia valley and thence falls rapidly to Chiavenna. But if we examine the watercourses immediately south of Maloja and descending into the Bargaglia valley, we are confronted by the remarkable phenomenon that several of the principal glaciers and torrents emerging from them, run in a north-easterly direction, and that after a certain distance the torrents suddenly turn south-west at a sharp angle. Thus, the Meira or principal river of the Bargaglia valley, takes from the confluence of its two branches below the Septimer Pass at an altitude of 2000 metres or about 6600 feet, a north-easterly course through the Marozzo valley, in the direction of Maloja, until after a run of about 2800 metres, it describes a curve to the S.W., and enters the Bargaglia valley near Casaccia, about two miles below Maloja. On the opposite side of the valley the case is even more striking. From the Forno glacier trending N.E., emerges at an altitude of about 2000 metres, or 6600 feet, the Orlegna, which flows in the same N.E. direction, until close to, and practically on a level with Maloja, it deviates by a sharp curve to S.W., and following the foot of the wall dividing the watersheds, flows into the Meira below Casaccia. No less remarkable is the course of the Albigna, which after emerging from the glacier of the same name at an altitude of 2064 metres or 6800 feet, keeps for about a mile the same direction as the glacier, viz. N.E. parallel to that of the Forno, and more or less in the direction of Maloja, where it suddenly turns S.W., at an angle of 50 degrees, and flows into the Meira near Vicosoprano. The course of these two rivers and that of their glaciers runs parallel to all the tributaries of the Upper Engadine lakes, such as those of the Val Fedo, the Val Fex, the Bernina, and others, whilst the Meira in its upper course runs parallel to the Julier and St. Moritz torrents and the smaller tributaries of the lakes on the other side of the Engadine valley. Below Vicosoprano, all the torrents run more or less at right angles to the Bargaglia valley, viz. they follow a normal course.

We have, thus, the three principal rivers of what is now the Bargaglia valley, viz. the Meira, the Orlegna, and the Albigna,—the two last named with their glaciers—rising at much the same altitude, viz. about 7000 feet and pointing in their upper courses in the direction of Maloja, or North of the Alps, while in their lower courses they are deflected to the S.W., or South of the Alps. It follows that these three rivers were the principal tributaries if not the actual sources of the ancient Inn, the confluence of the three being at Maloja, as is evidenced by the large superficial area of that plain which first formed a trough and was subsequently filled up by the deposits of the three rivers. The distance from the points where the rivers, the Meira, Orlegna and Albigna rise, to the ancient Maloja confluence is six, four, and eight kilometres, and the fall at the rate 3·6, 4·4, and 3·2 per cent. respectively, which is practically the same as that of the two principal tributaries of the Sils and Silvaplana lakes, the Fedo and the Fex of 3·6 per cent. The crest line of the old divide of the Engadine and Bargaglia river systems was therefore fully six miles south of Maloja, and stretched almost at right angles across the present Bargaglia valley near Vicosoprano; for it is on a line drawn from the Pizzo della Duana (3133 metres) to the Cima Bondarca (3288 metres) that we strike on one side the sources of the Meira, and on the other, the upper terminals of the Albigna and Forno glaciers from which emerge the Albigna and Orlegna, all trending N.E., whilst to the south of this line of demarcation the valleys trend distinctly in the opposite direction. Not improbably from the central part of this old divide whose crest line was at about 3000 metres altitude, there descended to the north a glacier which was one of the main spings of the old Inn, and whose torrent joined the other three at Maloja.

In Prof. Heim's opinion, the remarkable deflection from north to south of these three torrents, viz. the Meira, the Albigna and Orlegna, was brought about by the greater erosive power of the torrents descending on the south of the Vicosoprano crests line into the Bargaglia valley, whereby the divide was gradually scooped out, worn down, and pushed back until the valley receded to above Casaccia and below Maloja, viz. to the present divide.[1] But this hypothesis appears untenable, when it is considered that as long as the divide of Vicosoprano existed, the principal river of the then Bargaglia valley and its tributaries must have been very insignificant, and their erosive power, in spite of their great fall, quite insufficient to excavate backwards, even to the Albigna, a mountain barrier 6600 feet in vertical depth and composed, like the massifs of the Bargaglia and Engadine ranges generally, of granitic gneiss, and hornblende schists. The deflection of the Meira, Albigna, and Olegna from their former course can only have been produced in the first instance by a subsidence of the old divide, whereby a basin or trough was formed between Vicosoprano and Maloja, and the three powerful torrents now turning to the south, and gaining considerably in fall were able to erode the remainder of the divide at Vicosoprano and form the Bargaglia valley of the present day. The subsidence and consequent formation of the Casaccia trough is attested not only by the general configuration of that trough and by the defile of Vicosoprano, but also by the quasi-perpendicular wall or drop of 800 feet immediately below Maloja, no less than by the Albigna which in its upper course of about a mile, viz. before its deflection to the south, now falls from 2000 to 1200 metres, equal to a fall of no less than 34·6 per cent. or more than ten times its old fall to the Engadine. The erosive action of the rivers and torrents below as well as above Vicosoprano was therefore only the secondary cause, the primary cause being a subsidence; and this explanation tallies, moreover, remarkably well with Professor Heim's own and latest views with regard to the origin of the principal Alpine lakes as the effect of a subsidence of the massif of the Alps between the first and second glacial epochs, to which views I propose to refer in a future communication.

---

[1] Swiss Alpine Club, 1879–80.—When Prof. Heim attributes the receding of the valley and of the divide to the backward erosive action of the Meira, it is not very clear whether he refers to the principal torrent south of the old divide, or to the Meira of the present day, the former tributary or one of the sources of the Inn. If the former, it would not be the Meira at all; if the latter, the Meira assuredly could not run and erode to the south until the old divide had disappeared. In the meta-

The effect of the deflection of the original sources of the Inn system to the south, by which the Upper Engadine valley was deprived of its principal agents of erosion, was the gradual formation of the Sils, Silvaplana, Campfer, and St. Moritz lakes. From a powerful Alpine river, the Inn at Maloja was reduced to a small torrent which had neither sufficient volume nor sufficient fall to wash out and carry away the deposits brought down by lateral torrents between Maloja and Camadon; hence these deposits filled and raised its bed, and thus the lakes whose average depth is about 350 feet were formed by the weakened river being banked up at various points.[1] Thus the deposits of the Val Fex torrent banked

---

phorical phraseology in which he delights, that distinguished geologist speaks of the "tremendous fight between the Meira and the Inn which ended not only in the complete discomfiture of the latter but also in the Orlegna and Albigna forsaking their old allegiance." It is difficult to see how there could be a fight, because—to follow up the metaphor—the Inn was simply a passive looker-on, and the Meira and the other two rivers turned naturally to the south when an opening was made for them, giving them a greater fall.

[1] From measurements made by the writer the combined drainage area of the Meira, Orlegna, and Albigna within the old (Vicosoprano) divide, is about 120 square kilometres (44 square miles); that of the four lakes from the present (Maloja) divide to the lower end of St. Moritz lake is 140 square kilometres (51 square miles); and that of the present Inn torrent rising in the lake Lunghino, is 16 square

the river at Sils, forming the Sils lake, while this, the largest of the Engadine lakes, will at no distant time be itself divided into two by the débris-cone of the Val Fedo torrent, which cone is gradually stretching across to the rocky spur on the other side. The next two lakes, that of Silvaplana and Campfer, were originally one, being formed by the deposits of St. Moritz torrent at Campfer, and were subsequently divided by the Julier torrent at Silvaplana. The St. Moritz lake alone presents somewhat different conditions, the bar being in this case not alluvial but older deposit rising above the lake level to a height of about 500 feet, through which the river has cut as yet only a narrow channel or rapid of one kilometre in length, having a total fall of 43 metres or 4·3 per cent. viz. ten times the fall and mechanical energy of the upper course. But it is only near Samaden that the Inn, by the addition of the Bernina and Val Roseg torrents, having a drainage area of 200 square kilometres and a volume of 13 cubic metres or tons per minute becomes a true Alpine river and then attains sufficient volume and fall (22 cubic metres or tons per minute) to cut through and wash away the lateral deposits, to exert its erosive energy to its full extent, and thus to prevent the formation of lakes further down the valley.

The hydrographic changes brought about, in the first instance, by the subsidence or dislocation of the old divide of the Inn and Bargaglia systems, and by the consequent deflections to the south of the original Inn sources, are the more striking when we consider the enormous difference between the fall of the two river systems North and South of the Alps respectively. The entire course of the Inn from Maloja (1810 metres) to its confluence with the Danube at Passau (290 metres), where in volume it greatly exceeds the latter, is 400 kilometres or about 250 miles, the average fall being therefore at the rate of 0·4 per cent., whilst in the Upper Engadine from Maloja to Samaden, a distance of about 16 miles, the fall is 100 metres, or 0·4 per cent., viz. not above the average. The Meira, on the other hand, has from Casaccia (1460 metres) to Chiavenna (317 metres) in a distance of 22 kilometres or 14 miles a fall of no less than 1143 metres or 5·5 per cent., viz. more than ten times

kilometres (six square miles). Taking the rainfall in those Alpine valleys at 2·5 metres per annum, less 25 per cent. for absorption and evaporation, or in round figures at 2 metres (6·56 feet), the quantity of water of the three drainage areas respectively worked out as follows:

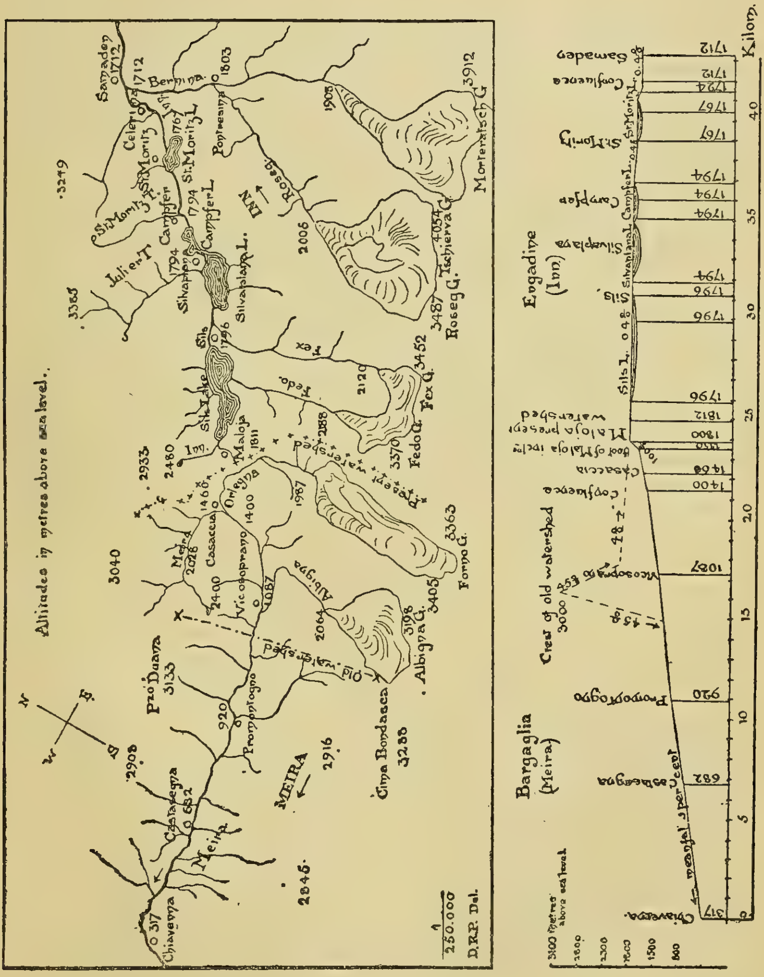
Meira, Orlegna, and Albigna, $\frac{120 \times 1{,}000{,}000 \times 2}{365 \times 24 \times 60} = 438$ cub. metres or 15,460 cub. ft. per min.

Up. Engadine lakes, $\frac{140 \times 1{,}000{,}000 \times 2}{525{,}600} = 533$,, ,, 18,820 ,, ,,

Inn torrent, $\frac{16 \times 1{,}000{,}000 \times 2}{525{,}600} = 69$,, ,, 2,440 ,, ,,

The old Inn carried therefore, at the present outflow of the St. Moritz lake, about 1000 cubic metres or tons per minute, which quantity the deflection of the Meira, Orlegna and Albigna reduced to about one half, whilst the present Inn at Maloja only carries about one-sixth of the volume of the old river, the erosive power being reduced in the same proportion.

that of the Inn; the erosive energy it developes being in direct proportion to its volume and fall; whilst its velocity is, of course, the greater the more confined is its bed. As has been shown, it is the loss of that erosive agency and energy in the Upper Engadine by the deflection to the south of the old Inn sources that has led to the formation of the four lakes; in other terms they owe their origin to the slackening and partial stoppage of fluvial, but never to glacial erosion.



V.—Note on the Growth of Lake Geneva.

By Charles Davison, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

THOUGH the observations described in this note are not conclusive, they seem to me to show that the lake of Geneva is probably growing at the present time, and that a similar growth, if taking place beneath an ice-covering[1] on nearly level ground, would in time produce a true rock-basin. Unfortunately, the instruments used were very delicate levels, and experiments with such instruments prove that they are not to be trusted entirely for measurements of very small angles continued over a long interval of time.[2]

The observations referred to were made for several years by M. Ph. Plantamour at Sécheron, near Geneva. I have given some account of them in a former paper,[3] and will now only repeat those particulars which bear immediately on the present subject.

Sécheron lies on the west shore of the lake, about a mile and a quarter north of the observatory of Geneva. The shore-line here runs about 30° E. of N. and 30° W. of S. and the slope of the ground must be roughly in a direction at right angles to this, *i.e.* about 30° S. of E. One of the levels is placed east and west, the other north and south. They show that, from day to day, the inclination of the ground which forms the floor of M. Plantamour's cellar is incessantly changing. The most noticeable movements are periodic, and are clearly caused by the annual and diurnal changes of external temperature. But we can eliminate these very nearly by calculating the average inclination throughout the year towards the east and north. This is done in the following table for the third to the eighth years, reckoning the average inclination during the third year as zero :—

	East.	North.
3rd year (Oct. 1, 1880—Sept. 30, 1881). ...	0″	0″
4th ,, (,, 1881— ,, 1882). ...	5·55	1·11
5th ,, (,, 1882— ,, 1883). ...	5·07	2·92
6th ,, (,, 1883— ,, 1884). ...	11·66	3·82
7th ,, (,, 1884— ,, 1885). ...	18·82	5·60
8th ,, (,, 1885— ,, 1886). ...	16·99	7·60

The inclinations during the first year are omitted because the N.S. level was not placed in position until nearly three months had elapsed; and those of the second year, on account of an unusually great movement in a direction somewhat south of east, which, of course, affected the readings of both levels. After the eighth year the N.S. level was removed and placed in an E.W. direction nearer the middle of the house. The result of this change was to show, I believe, that the periodic movements indicated by the E.W. level may in part arise from bendings in the walls of the house, caused by the expansion and contraction of the roof.

---

[1] See Prof. Judd's paper "On the Origin of Lake Balaton, in Hungary," Geol. Mag. Vol. III. 1876, p. 12.

[2] If similar observations were made for a few years in different parts of Switzerland with a suitable instrument, such as the horizontal pendulum of Dr. E. von Rebeur Paschwitz, or the bifilar pendulum of Mr. Horace Darwin, the labour and money spent would meet with a rich reward. In this country observations of great interest might be made near the north-east end of Loch Ness, say at Aldourie or Dores.

[3] Phil. Mag. Vol. xxvii. 1889, pp. 189–199.

Referring to the above table, it will be seen that the inclination towards the east changed rather irregularly, in three years being considerable and in the other two slightly retrograde. During the second year of the observations there was an extraordinary movement of 1½ minutes between Nov. 13, 1879, and Jan. 28, 1880, in a direction a little south of east. The masonry on which the levels rested is not, however, totally disconnected from the structure of the house; and it seems to me most probable that the non-periodic movements indicated by the E.W. level are due to a settling of the house in the line of greatest slope of the ground outside.

On the other hand, the change of inclination towards the north has taken place much more regularly, the annual change varying from $0''\cdot90$ to $2''\cdot00$, and being $1''\cdot52$ on an average for the five years.[1] So far as I am aware, there is nothing of a purely local character to account for this movement. It seems to be independent, or nearly so, of that which takes place in an easterly direction; for it may exist without the latter. There can hardly be any creeping of the soilcap or settling of an old house along a line nearly at right angles to that in which the land dips and in reality inclining upwards. It is possible that the levels may be at fault, for, as before remarked, they are by no means perfect instruments; but the regularity of the movements is in favour of the view that they are caused by a real tilting of the ground itself, a tilting which must result in the very slow but still measurable growth of the Lake of Geneva.

VI.—The Geological Development, Descent and Distribution of the Mammalia.

By Prof. Karl A. von Zittel, Ph.D., For. Memb. Geol. Soc. Lond.

Professor of Palæontology in the University of Munich.

(*Continued from page* 412, Vol. X. September, 1893.)

In addition to the localities in Europe and N. America, another area for Tertiary Mammals has in very recent times been laid open to view in the Southern part of Argentina, which promises in the wealth of its contents to exceed those previously known. A few scattered remains from the Tertiary beds of the neighbourhood of Santa Cruz in Patagonia were already known more than forty years ago, but it is only lately, through the work of Burmeister and Moreno, and more particularly through the indefatigable researches of Florentino Ameghino, that a more complete insight into this very remarkable fauna has been obtained. It is imbedded in fresh-water deposits, from 60 to 80 mètres in thickness. The following genera are known up to the present from the Santa Cruz Formation:—

---

[1] If this rate were to continue uniform, a change of inclination of ten degrees would be produced in 23,684 years. The rate is, however, probably greater than this; for, since the ground slopes in a direction south of east, movements in this direction affect the inclination of the N.S. level.

MARSUPIALIA.
Eodidelphys.
Prodidelphys.
Microbiotherium.
Stylognathus.
Hadrorhynchus.
Prothylacinus.
Perathereutes.
? *Borhyæna.*
? *Acrocyon.*
? *Agustylus.*
? *Hathlyacinus.*
? *Dinamyctis.*
? *Conodinyctis.*
? *Anatherium.*
? *Sipalocyion.*
? *Acyon.*
? *Ictioborus.*
? *Cladosictis.*
? *Protoproviverra.*
Abderites.
Acdestis.
Decastis.
Epanorthus.
Callomenus.
Halmadromus.
Halmaselus.
Essoprion.
Pichipilus.
Garzonia.
Halmariphus.

EDENTATA.
a. Vermilinguia.
Scotæops.
b. Tardigrada.
Entelops.
Dideilotherium.
c. Gravigrada.
Zamicrus.
Hapalops.
Pseudhapalops.
Amphihapalops.
Schismotherium.
Trematherium.
Nematherium.
Geronops.
Analcimorphus.
Eucholœops.
Hyperleptus.
Xyophoros.
Planops.
Paraplanops.
Metopotherium.
Eurysodon.
Tolmodus.
Prepotherium.
Lymodon.
Analcitherium.
Ammotherium.

d. Glyptodontia.
Cochlops.
Eucinepeltus.
Propalæohoplophorus.
Asterostemma.

e. Dasypoda.
Dasypus.
Chlamydotherium.
Peltephilus.
Stegotherium.
Prozædyus.
Proeutatus.
? *Anticsodon.*

PERISSODACTYLA.
a. Proterotheridæ.
Diadiophorus.
Licaphrium.
Thoatherium.
Proterotherium.

b. Macrauchenidæ.
Theosodon.
Cœlosoma.
Pseudocœlosoma.

TOXODONTIA.
Nesodon.
Adinotherium.
? *Gronotherium.*
? *Xotoprotodon.*
? *Acrotherium.*
? *Phobereotherium.*
? *Nannodus.*
? *Rhadinotherium.*
? *Palæolithops.*
Astrapotherium.
? *Listriotherium.*
? *Astrapodon.*
Homalodontotherium.
? *Diorotherium.*
Colpodon.

TYPOTHERIA.
Protypotherium.
Patriarchus.
Interatherium.
Icochilus.
Hegetotherium.

RODENTIA.
Steiromys.
Acaremys.
Sciamys.
Scleromys.
Adelphomys.
Stichomys.
Olenopsis.
Spaniomys.
Neoreomys.
Hedimys.
Phanomys.
Eocardia.
? *Procardia.*
? *Dicardia.*
? *Tricardia.*
Schistomys.
Sphæromys.
Sphodromys.
Sphingomys
Perimys.
Pliolagostomus.
Prolagostomus.
Lagostomus.
Scotoeumys.

PRIMATES.
Homunculus.
? *Homocentrus.*
Anthropops.
? *Eudiastatus.*

The composition of this Patagonian Tertiary fauna, which according to Ameghino is preceded by some older mammalian remains, intermingled with some probably Dinosaurian and Crocodile bones, stands in the strongest contrast with the Mammalia occurring in the Eocene of Europe. Of the 121 genera introduced above, with at least 220 species, a notable proportion will very likely not stand critical examination, but in any case the fossil mammalian fauna of Santa Cruz notably exceeds, in its wealth of genera and species, that now existing in Argentina, which according to Ameghino only contains 107 species, and it is in this point of view equally comparable with that of the Upper Eocene of Europe. Ameghino increases the list further by three alleged Amblypoda (*Planodus, Adelotherium, Adrastotherium*) and a Tillodont (*Entocasmus*), but these additions are based on remains which absolutely do not permit of satisfactory determination. In comparison with the Europeo-American Eocene fauna, the complete absence of the Artiodactyla, Insectivora, Chiroptera, Carnivora and Prosimiæ, is very striking. The Perissodactyla are represented by two entirely novel extinct families (Proterotheridæ and Macrauchenidæ); the Rodents entirely by Hystricomorphous forms of a specifically South American type, and equally so the Primates by the Platyrhine Apes. The fauna is mainly composed of Marsupials, Edentates, Toxodonts and Typotheria. Only South America possesses representatives of these two last orders, which make their appearance in the Santa Cruz formation and become extinct in the Pampas formation. Also all the forms of Edentates belong to the Xenarthra, which now live exclusively in South America, and amongst the Marsupials, the most prominent are the Didelphyidæ, which still live all over America and in the Tertiary period were distributed over the Northern hemisphere, but these are accompanied by other forms of the same order which show an Australian stamp. Ameghino has placed these in part with the Dasyuridæ and in part with the Creodontia, but as regards the last he is now himself doubtful, and acknowledges[1] that a part at least of the supposed Creodontia may belong to the Marsupials. The same may be said of the supposed Plagiaulacidæ, on which Ameghino had mainly relied to determine the age of the Santa Cruz formation.[2] These also probably form an independent family of Marsupials, either indigenous or possibly migrated from Australia.

Under any circumstances South America must be considered as an independent "centre of creation," which possibly at an early period had been ingrafted from Australia, but which already in the Santa Cruz formation had produced peculiar forms of Marsupials. In favour of a connection with the mammalian fauna inhabiting Europe and North America at the same time, there is, in spite of the assurances of Ameghino, no ground of support. On the other hand it cannot be denied that there is some authority for the supposition of Ihering, based on the distribution of the fresh-water animals, that South America, during the Mesozoic and Older Tertiary periods, was connected by land with Australia and South Africa. The associated group of animals which the investigations of Ameghino has brought to light in Patagonia is new and altogether peculiar, and in it are to be found the ancestors of the Edentates, Rodents and Apes of the present neotropical kingdom.

---

[1] Revista Argentina, I. p. 314.

[2] The examination of a great number of lower jaws and detached teeth of the genera *Abderites*, *Acdestis* and *Epanorthus*, which I owe to the kindness of Señor Ameghino, shows that the molars in these genera do not agree, either in number or in form, with those of *Neoplagiaulax*. They greatly resemble those of the Australian Hypsiprymnidæ, and they are proved to be genuine Marsupials by the incurved angle of the lower jaws. Ameghino also acknowledges them (Revue génér. des Sciences, 1893, p. 77) as Diprotodont Marsupials, to which he also further assigns *Plagiaulax*, *Neoplagiaulax* and *Ptilodus*.

There are great difficulties in the way of precisely determining the age of a fauna thus new and circumscribed, more particularly since the geological relations do not yield any definite information. The Santa Cruz beds rest directly on the "Guaranian formation," the lower portion of which consists of marine deposits, undoubtedly belonging to the Cretaceous; whilst the upper consists of conglomerates and coarse sandstones, in which the remains of Opisthocœlous Crocodiles and Dinosaurs (?) and the imperfectly preserved mammalian fragments mentioned above (*Macropristis*, *Pyrrhotherium*, etc.) have been discovered. The Santa Cruz formation is overlaid by flows of Basalt, and it forms the foundation for the marine deposits with *Ostræa Patagonica*, *Pecten Paranensis*, and a great number of other fossil shells which have been already examined by D'Orbigny, Darwin and Bravard, and determined to be Tertiary. Darwin held the marine deposits to be Eocene, D'Orbigny, Miocene, and Ameghino, Oligocene. Direct points of comparison with North American or European Tertiary strata are here also wanting, so that the age of the Santa Cruz and Patagonian formations must be wholly determined from the general character of the fossil remains.

Ameghino places the mammalian fauna of Santa Cruz in the Eocene. That, however, the existence of Amblypoda, Tillodontia, Creodontia, and Plagiaulacidæ cannot be advanced in favour of this view, has already been mentioned. Amongst the Marsupials, forms of a distinctly ancient stamp are wanting, and in particular one fails to find close ties to the Mesozoic Polyprotodontidæ and Allotheria. Amongst the Perissodactyla, the Macrauchenidæ stand on a primitive rank as regards their dentition and the structure of their extremities, when compared with their later successors in the Pampas formation; on the other hand the Proterotheridæ, which, as regards their dentition, may be the most readily compared with the Anoplotheridæ and Palæotheridæ, have far outran these latter in the reduction of the lateral metapodials and in the complete differentiation of the extremities. The remarkably numerous and varied Edentates do not in the least correspond with the ideas which one is justified in holding respecting the ancestors of this order. They remain, indeed, in size far behind the giant forms of the Pampas formation, but they are already just as distinctly divided into sub-orders (Vermilinguia, Tardigrada, Gravigrada, Glyptodontia and Dasypoda) as in the Pleistocene, and they stand in all the important features of the dentition and build of the skeleton, on a high grade of differentiation. The molars are already of a prismatic form, incisor teeth are only known in two genera, and a change of teeth appears to have taken place just as seldom as in the majority of living Edentates. Skull and skeleton do not materially differ from those of younger genera, and the characteristic dermal shields of the Glyptodonts and Dasypoda from the Santa Cruz formation are in reality built up like those of Pleistocene and living genera. According to Ameghino even two existing genera (*Dasypus* and *Chlamydotherium*) make their appearance in the Santa Cruz formation. The Edentates cannot, therefore, be appealed to as witnesses for the ancient character of the fauna. Just as little can the Rodents. These also belong exclusively to Hystricomorphous forms of a specifically South American stamp, and they are in part very closely connected with genera still living or even altogether identical with them (as *Lagostomus*). Their supposed relations to the European Protrogomorpha (*Theridomys, Nesokerodon, Archæomys*) have proved deceptive, and the same is also the case with regard to the North American Tertiary Rodents. The mostly high prismatic teeth and the absence of a milk dentition are proofs that the Rodents of the Santa Cruz formation have on the whole reached a higher grade of development than their Upper Eocene relatives in Europe and North America. Amongst the Toxodonts only the Homalodontotheridæ show primitive features; all the rest have a highly differentiated dentition, mostly prismatic molars and reduced extremities. In the Typotheria the generally closed rows of teeth and the five-toed extremities betray a more primitive condition than in their successors of the Newer Tertiary and of the Pampas formation, but even in this group the curved molars have already reached a prismatic form. Finally, the Apes can in no wise be considered as the stock from which all our present Simiæ have descended, for they have a definite South American stamp, and, as regards differentiation, they stand markedly above the more generalised Pachylemuridæ of the European and North American Tertiaries.

Taken all in all, the Santa Cruz fauna has distinctly reached a higher rank than the mammalian groups in the Lower and Middle Eocene of the Northern hemisphere. It can, at the furthest, be placed on a parallel with the Upper Eocene or with the Oligocene of Europe.

OLIGOCENE.

The coal-bearing Lower fresh-water Molasse of the North and South Alps (Upper Bavaria, Switzerland, near Vicenza, Cadibona and Zovencedo in Liguria) and of the Waadtländer highlands (Rochette, near Lausanne); the contemporaneous deposits in Hungary (Gran) and Dalmatia (Monte Promina); the marine sands and brackish marls of the Mayence basin; of the Upper Rhine valley (Lobsann); of the neighbourhood of Paris (Fontainebleau, Etampes); the fresh-water marl of Ronzon near Le Puy, Villebramar, St. Henri, Manosque, and other places in the South of France, and the lacustrine deposits of Hempstead and Colwell Bay in the Isle of Wight, contain a scanty mammalian fauna composed of the following genera :—

MARSUPIALIA.
Didelphys.
Amphiperatherium.

PERISSODACTYLA.
Aceratherium.
? *Ronzotherium.*

ARTIODACTYLA.
Anthracotherium.
Ancodus.
Elotherium.
Plesiomeryx.
Gelocus.

RODENTIA.
Theridomys.
Cricetodon.
? *Decticus.*
? *Elomys.*

Insectivora.
Tetracus.

Creodontia.
Hyænodon.

Carnivora.
Cynodon.
Amphicynodon.
Plesictis.
? *Elocyon.*

Sirenia.
Halitherium.

Cetacea.
? *Squalodon.*
? *Balænoptera.*

The Oligocene mammalian fauna only maintains any claim to independence through the abundant occurrence of *Anthracotherium, Ancodus* and *Elotherium.* It shares nearly all its genera with the Upper Eocene, of which it shows itself an impoverished descendant. The absence of a considerable number of genera flourishing in the Upper Eocene is worthy of note (*Anoplotherium, Diplobune, Xiphodon, Palæotherium, Paloplotherium, Anchilophus, Pterodon, Proviverra*, etc.).

Miocene.

I. The fresh-water deposits, referred to the Lower Miocene, of Limagne (St. Gérand-le-Puy, Cournon, Gannat, etc.), of the Paris basin (Calcaire de Beauce), of the neighbourhood of Mayence (Weisenau, Hochheim, Mombach), Ulm (Haslach, Eckingen, Michelsberg, Eselsberg) contain a tolerably rich and characteristic mammalian fauna which, unfortunately, has only been discovered in a few European localities. It consists of the following genera:[1]—

Marsupialia.
†**Didelphys.**
(*Oxygomphius.*)
†*Amphiperatherium.*

Perissodactyla.
***Tapirus.**
Aceratherium.
***Rhinoceros.**
(**Diceratherium.**)
? *Macrotherium.*

Artiodactyla.
†**Anthracotherium.**
†**Palæochœrus.**
*†**Amphitragulus.**
†**Dremotherium.**
†**Cænotherium.**
†**Plesiomeryx.**

Rodentia.
†**Theridomys.**
*†**Archæomys.**
*†**Issiodoromys.**
**Myoxus.*
Cricetodon.
**Spermophilus.*
Sciurus.
***Steneofiber.**
*†**Titanomys.**

Insectivora.
**Talpa.*
*†*Geotrypus.*
*†*Echinogale.*
***Myogale.**
*†*Plesiosorex.*
Sorex.
***Dimylus.**
*†*Cordylodon.*
*†*Palæoerinaceus.*
**Erinaceus.*

Cheiroptera.
†**Palæonycteris.**
? *Vespertilio.*

Creodontia.
†**Hyænodon.**

Carnivora vera.
(Fissipedia.)
†**Cephalogale.**
***Amphicyon.**
Stenogale.
†**Plesictis.**
Palæogale.
***Potamotherium.**
†**Amphictis.**
Viverra.
***Herpestes.**
***Proælurus.**

At the first glance this fauna can be recognized as a descendant also of the Upper Eocene and Oligocene faunas. The same orders, and frequently also the same genera, are repeated in all three, and the percentage division of the particular orders shows also considerable uniformity. In the absence of Lemurs, in the marked decline and final extinction of the Marsupials, Creodontia and Anoplotheridæ, in the much greater abundance of particular genera which were of only sporadic occurrence at an earlier period, such as *Anthracotherium,*

---

[1] The genera marked with * appear for the first time; those with † become extinct, and those marked *† appear in the Lower Miocene and likewise die out in the same.

Palæochœrus and *Dremotherium*, and in the springing up of a considerable number of new genera, as *Tapirus, Diceratherium, Amphitragulus, Steneofiber, Titanomys, Erinaceus, Dimylus, Amphicyon, Potamotherium, Herpestes, Proœlurus*, and others, depend the differences between the Upper Eocene, the Oligocene and the Lower Miocene faunas of Europe. Amongst the new genera there is, further, no single form for which a corresponding related form could not be found in the Eocene; only in the modification, differentiation and improvement of the older types is the new fauna distinguished from the earlier one. With the exception of some Marsupials, Rodents, Insectivora and Bats (*Didelphys, Myoxus, Cricetodon, Spermophilus, Sciurus, Talpa, Myogale, Sorex, Erinaceus, Vespertilio*), all the larger genera are extinct.

The rich mammalian fauna of the so-called White-River beds, which in North Nebraska, Dakota, Colorado, Wyoming and South Canada cover a very extended area, and reach a thickness of from 40—60 mètres, holds an altogether similar relationship to the Bridger and Uinta fauna, as the fauna of the Lower Miocene of Europe to that of the Upper Eocene and Oligocene. The powerful Amblypoda and the peculiar Tillodontia are extinct, the Creodontia are shrunk up to a single genus (*Hyænodon*); the Prosimiæ are, however, still represented by two genera. For the rest, the White-River fauna consists of Marsupials, Perissodactyla, Artiodactyla, Rodents, Insectivora, Bats, and genuine Carnivora, and the following genera are present in it:[1]—

MARSUPIALIA.
Didelphys.

PERISSODACTYLA.
*†**Mesohippus.**
*†*Tapiravus.*
***Aceratherium** (E.)
*†**Hyracodon.**
*†*Metamynodon.*
*†**Titanotherium.**
- *Diconodon.*
- *Brontops.*
- *Brontotherium.*
- *Menops.*
- *Symborodon.*
- *Megacerops*
- *Titanops.*
- *Allops.*
- *Dalodon.*
- *Teleodus.*

ARTIODACTYLA.
*†?*Ancodus* (E.)
*†**Elotherium** (E.)
*†*Perchœrus.*
*†*Leptochœrus.*
***Agriochœrus.**
*†**Oreodon.**
*†**Poëbrotherium.**
*†*Gomphotherium.*
*†**Leptomeryx.**
*†*Hypisodus.*
*†*Hypertragulus.*
*†*Protoceras.*

RODENTIA.
*†**Ischiromys.**
***Steneofiber** (E.)
*†*Heliscomys.*
*†**Gymnoptychus.**
*†**Eumys.**
*†**Palæolagus.**

INSECTIVORA.
†*Ictops.*
*†*Leptictis.*
*†*Mesodectes.*
*†*Geolabis.*

CHIROPTERA.
*†*Domnina.*

CREODONTIA.
***Hyænodon** (E.)

CARNIVORA VERA.
(Fissipedia.)
*†**Daphænos.**
***Galecynus.**
***Hoplophoneus.**
*†**Dinictis.**

PRIMATES.
*†*Laopithecus.*
*†*Menotherium.*

Amongst the Perissodactyla, *Mesohippus* represents only a somewhat more advanced stage of differentiation of *Epihippus*, and exactly in the same manner *Tapiravus* is related to *Helaletes*, *Hyracodon* to *Hyrachyus*, *Metamynodon* to *Amynodon*. The Titanotheridæ, with an abundance of species, form, by their gigantic dimensions and their great numbers, a highly characteristic element of the White-River fauna, and they are plainly descended from the Eocene Palæopsinæ. Amongst the Artiodactyla, the Oreodontidæ (*Agriochærus, Oreodon*), as regards their abundance, take the first place; they are also already represented in the Uinta beds by *Protoreodon*; in a like manner *Poëbrotherium* and *Gomphotherium* show that they are progressive connecting links between the existing Camels and the Eocene Leptotragulidæ. The micro-fauna of the White-River beds is also closely connected with that of the Eocene; on the other hand, the genuine Carnivora, the Tragulidæ (*Leptomeryx, Hypisodus, Hypertragulus*), the remarkable cervine genus *Protoceras*, as also some genera which have probably migrated from Europe (*Aceratherium, Ancodus, Elotherium, Steneofiber, Hyænodon*), stand forth as new forms. It is evident that there was still intercourse between Europe and North America, but whilst in the Older Eocene the new world made a present of its superfluity to Europe, in the Miocene period North America received a greater number of immigrants from Europe.

---

[1] The genera to which the letter (E.) is affixed occur also in the Miocene of Europe. For the other marks see the note on p. 460.

II. In the Newer Miocene period the area of distribution of the terrestrial mammals in Europe became notably extended. The district between the Alps and the Jura-plateau, heretofore covered by the sea, was now laid dry, or sprinkled over with fresh-water lakes and bogs; in the Vienna basin also the sea is receding, in the Alps (Steiermark) and on the Jura-plateau (Steinheim, Nördlingen, Georgensgmünd) the depressions are filled up with fresh-water and contain the washed-in remains of land animals. A number of localities in the Rhone valley (Grive-St.-Alban), in Switzerland (Winterthur, Käpfnach, Elgg, Chaux-de-Fonds, Vermes), in Upper-Baden (Œningen, Engelswies, Heudorf), on the Swabian-Bavarian high-plateau (Kirchberg, Günzburg, Dinkelscherben, Haeder, Dachau, Munich, Freising, Lower Bavaria), on the Jura-plateau, in the Vienna basin, Steiermark, Hungaria, Roumania, and Bessarabia contain the remains of land mammals, which also are again found to the west of the Central-plateau of France, in the former Aquitanian basin, now deserted by the sea (Sansan, Simorre, St. Gaudens), in Touraine and in the Orléanais, and they have also been discovered in Spain (San Isidro) and Algeria. Italy (Monte Bamboli) has at least yielded traces of the same. The Newer or Middle Miocene fauna consists of the following genera:[1]—

PERISSODACTYLA.
*†Anchitherium.
Tapirus.
Aceratherium.
Rhinoceros.
(_Dihoplus._)
†Macrotherium.

ARTIODACTYLA.
*†Hyotherium.
*_Chœrotherium._
*†Listriodon.
*Hyæmoschus.
(_Dorcatherium._)
*†Palæomeryx.
*_Procervulus._
*†_Micromeryx._
*†Dicroceras.
*†_Protragoceras._

PROBOSCIDIA.
*Mastodon.
*Dinotherium.

RODENTIA.
Sciurus.
Steneofiber.
Cricetodon.
Myoxus.
*_Hystrix._
*Myolagus.
*Lagomys.

INSECTIVORA.
Talpa.
*†Galerix.

---

[1] See note on p. 460.

*†*Lanthanotherium.*
Myogale.
Erinaceus.
Sorex.
Crocidura.
†*Dimylus.*

CHIROPTERA.
Vespertilio.
Vesperugo.

CARNIVORA.
(Fissipedia.)
*†*Galecynus.*
†**Amphicyon.**
*†*Pseudocyon.*
*†*Hemicyon.*
*†**Dinocyon.**
***Hyænarctos.**
*†*Haplogale.*
†*Stenogale.*
*†*Pseudictis.*
†*Palæogale.*
*†*Proputorius*
**Mustela.*

*†**Trochictis.**
*†*Trochotherium.*
**Enhydriodon.*
Viverra.
Herpestes.
*†*Progenetta.*
†*Pseudælurus.*
***Machairodus.**

PRIMATES.
*†**Dryopithecus.**
*†**Pliopithecus.**
*†**Oreopithecus.**

The sudden appearance of Proboscidians (*Mastodon, Dinotherium*) and of genuine Apes (*Dryopithecus, Pliopithecus, Oreopithecus*), the abundance of *Rhinoceros* and *Anchitherium*, the first occurrence of horned Ruminants (*Dicroceras, Procervulus*) and Antelopes (*Protragoceras*), the great development of carnivorous animals which, in their organization, are intermediate between dogs and bears, give to the fauna of the Middle Miocene a stamp fairly distinct from that immediately preceding it, and this is more intensified by the absence of small Cænotheria and Creodontia. The gap between the Middle Miocene and the Lower Miocene fauna is certainly a much larger one than that between this latter and the Upper Eocene fauna. No single species from the Lower Miocene has been preserved unchanged, and even the genera which have continued on from the earlier epoch belong, with the exception of *Aceratherium, Rhinoceros, Viverra, Herpestes*, and *Steneofiber*, to the Insectivora, Rodents, Bats and small Carnivora, which are well known to be only slightly subject to modification. Also the genera of that period, which are still in existence, are, with the exception of *Tapirus, Rhinoceros, Viverra*, and *Herpestes*, representatives of the micro-fauna, and they mostly have at the present time a cosmopolitan distribution. Of the four genera of the larger forms, *Tapirus* lives in India and South America, the three others in the Mediterranean region, Africa and South Asia, thus altogether in strikingly extensive areas of distribution.

The remarkable difference in the mammalian faunas of the Lower and Middle Miocene receives an explanation when it is considered that between them there are interposed, almost everywhere in Europe, thick marine deposits, which must, under any conditions, represent a long period of time, and these only contain remains of marine animals, and yield no information respecting the occupiers of the land in the same interval. The Miocene Thalassotheriæ all belong to extinct genera of Cetacea, Sirenia and Pinnipedia, concerning whose origin complete darkness prevails, as is likewise the case with their scanty forerunners in the Eocene (*Zeuglodon, Prorostomus, Halitherium*). That the shores of Europe and North America were inhabited by similar marine mammals in the Tertiary period follows, moreover, from the wide distribution of certain genera (*Zeuglodon, Squalodon*), and from the general agreement in character of the fossil Cetacea in the Miocene of Europe and in that of the United States (New Jersey, Maryland, Virginia, Georgia, Carolina). These contain the following genera:—

EUROPE.

CETACEA.
Squalodon.
Champsodelphis.
Trachyacanthus.
Delphinopsis.
Heterodelphis.
Priscodelphinus.
Schizodelphis.
Macrochirifer.
? *Cetorhynchus.*
Beluga.
Physodon.
Hoplocetus.
Plesiocetus.
Cetotherium.

SIRENIA.
Halitherium.
Rhytiodus.
Metaxytherium.
Miosiren.
Prohalicore.

CARNIVORA.
(Pinnipedia.)
Pristiphoca.
Monatherium.
Prophoca.
Mesotaria.

NORTH AMERICA.

CETACEA.
? *Delphinodon.*
? *Phocogeneus.*
Squalodon.
Zarhachis.
Ixacanthus.
Cetophis.
Lophocetus.
Priscodelphinus.
Rhabdosteus.
Agabelus.
Balænoptera.

SIRENIA.
? *Hemicaulodon.*

For the Middle Miocene land mammalian fauna also there is not wanting a parallel in North America. Hitherto only the extreme West, in the territories of Oregon, Nevada and Washington, has yielded those remains, in part so wonderfully preserved, which compose the John-Day fauna. The abundant occurrence of *Rhinoceros*, *Aceratherium*, *Anchitherium*, *Steneofiber*, *Sciurus*, *Lepus* and *Galecynus* shows that European genera could, at that time, still wander to the Pacific Ocean, and even although certain specifically American families, like the Oreodontidæ and the Camelidæ, have experienced a further evolution and increase in number, there are, nevertheless, not wanting representative forms from which a common origin and the former connection of both continents may be inferred. To the oldest horn-bearing mammal in Europe (*Dicroceras*) corresponds in North America *Blastomeryx*, to the remarkable Macrotheriæ and Chalicotheriæ of the old world, the American genus *Moropus*, and also between the Rodents and Carnivora of both continents there are many related links, although the lists mostly contain other names, which, however, mainly indicate similar forms. The fauna of the John-Day beds contains the genera mentioned below:[1]—

PERISSODACTYLA.
Anchitherium (E.)
Aceratherium (E.)
Rhinoceros.
(Diceratherium) (E.)
Moropus.

ARTIODACTYLA.
Boöchœrus.
Chænohyus.
Bothrolabis.
? *Thinohyus.*
Coloreodon.
Agriochœrus.
Merycochœrus.
Blastomeryx.

RODENTIA.
Allomys.
Sciurus (E.)
Steneofiber (E.)
Pleurolicus.
Entoptychus.
Hesperomys.
Paciculus.
Palæolagus.
Lepus (E.)

CARNIVORA.
(Fissipedia.)
Temnocyon.
Galecynus (E.)
Hyænocyon.
Oligobunis.
Enhydrocyon.
Nimravus.
Pogonodon.
Archælurus.
Hoplophoneus.

---

[1] The genera to which the letter (E.) is affixed occur also in Europe.

The outlines of the Newer Miocene fauna of North America have been extended by the discoveries in the so-called Deep-River or _Ticholeptus_ beds, which are at present known only in Western Nebraska, in the valley of Deep-River in Montana, and in Cotton-Wood Creek, Oregon. The fauna of these deposits is of a somewhat newer stamp than that of the John-Day beds. It is especially distinguished by the occurrence of _Mastodon_, by the great development of the Oreodontidæ (_Merycochœrus_, _Merychyus_, _Leptauchenia_, _Cyclopidius_, _Pithecistus_) and Camelidæ (_Protolabis_) and by the continuance of _Anchitherium_ and _Blastomeryx_. Altogether about 20 species are known from this horizon.

III. In Europe, also, at the close of the Miocene, a fairly radical change in the character of the land mammals takes place. The localities which disclose to us the Uppermost Miocene fauna are relatively few, and mostly widely apart from each other, but some of them are distinguished by the astonishing abundance and the excellent preservation of the remains which are found in them. Thus, for example, at Pikermi, near Athens, from an area of 300 m. in length and 60 m. in width, no fewer than 40 species of mammals have been dug up, and some of these are represented by hundreds of individuals, whilst some of the skeletons are entire. A similar necropolis of ancient mammals has been discovered in Samos, and another at Mount Léberon in Provence. Various localities in the Rhone valley, at the foot of the Pyrenees, in Spain, Algeria, and in Asia-Minor, show that the Pikermi fauna was widely distributed in the Mediterranean region. It is not altogether absent in the countries north of the Alps, but it is there somewhat poorer, it lacks, in particular, certain forms of Ruminants (Antilopidæ, Giraffidæ) which in the south were evidently surrounded by rich grass-bearing Steppes, and these are replaced by forest-loving Deer. The renowned sand-deposits of Eppelsheim near Worms, the Belvedere gravels near Vienna, and the widely-distributed Congeria beds of the Pontis division, in the Vienna basin, Hungaria and Roumania, contain the remains of the Uppermost Miocene fauna which by many authors is referred to the Pliocene. It is composed of the following genera:—[1]

EDENTATA.
*_Orycteropus._

PERISSODACTYLA.
*†**Hipparion.**
Tapirus.
Aceratherium.
Rhinoceros.
(_Dihoplus._)
*†_Leptodon._
? _Titanotherium._
*†**Chalicotherium.**

ARTIODACTYLA.
***Sus.**
Hyæmoschus.
(_Dorcatherium._)
Cervulus.
*†**Palæotragus.**
*†**Samotherium.**
*†**Helladotherium.**
***Camelopardalis.**
*†**Tragoceras.**
*†**Palæoryx.**
*†**Tragelaphus.**
*†**Palæoreas.**
*†_Antidorcas._
***Gazella.**
Antilope.

PROBOSCIDIA.
Mastodon.
†**Dinotherium.**

RODENTIA.
†**Steneofiber.**
*†_Acomys._
Hystrix.

INSECTIVORA.
Sorex.

CARNIVORA.
(Fissipedia.)
*†**Simocyon.**

---

[1] See note on p. 460.

CARNIVORA, *cont.*
†*Amphicyon.*
†**Hyænarctos.**
Mustela.
*†*Prometes.*
*†*Promephitis.*
*†**Ictitherium.**
*†*Lycyæna.*
*†*Hyænictis.*
***Hyæna.**
**Felis.*
Machairodus.

PRIMATES.
*†*Mesopithecus.*

The strangest constituent of this fauna is the Edentate genus *Orycteropus,* an African type which has maintained itself in the Southern hemisphere of the old world up to to-day. Also amongst the Ruminants, the Giraffes, Gazelles, and numerous Antelopes point to African connections, and they confirm the view that at that time there was a land junction between the Mediterranean region and the dark continent, over which herds of Ruminants traversed. Amongst these far-advanced, almost modern, types, *Helladotherium* and *Samotherium* stand out as relicts of an older period, and also *Mastodon, Dinotherium, Tapirus, Aceratherium, Rhinoceros, Chalicotherium* (which only differs slightly from *Macrotherium*), *Hyæmoschus, Cervulus, Steneofiber, Hystrix, Mustela* and *Sorex* support the continuity with the preceding Miocene fauna. Troops of a slim zebra-like horse (Hipparion) and genuine wild pigs of notable size inhabited at that time almost all Europe, and the abundance of wild game had a corresponding influence on the development of the Carnivora. Hyænas, Cats with powerful teeth (*Machairodus*), Civet-cats (*Ictitherium*), and the forerunners of Bears (*Simocyon, Amphicyon, Hyænarctos*) have yielded abundant remains, and they exceed in number the smaller genera (*Mustela, Promeles, Promephitis*) which have partly been taken over from the Middle Miocene. If there yet remained any hesitation as to the tropical character of this fauna, the occurrence in it of an Ape nearly related to the living *Semnopithecus,* of which dozens of skulls and entire skeletons have been dug up at Pikermi, would remove all doubt. Although the number of still existing races is not much greater than in the Middle Miocene, yet the Upper Miocene fauna wears a distinctly more modern dress, and in several groups it has already almost reached the standard of the existing fauna.

For the determination of the former distribution of the mammalia the discoveries made in different parts of Asia possess a high interest. From the renowned localities in the Sivalik Hills, at the southern foot of the Himalayas, between the Ganges and the Sutlej, Falconer and Cautley had already by the middle of this century reaped a rich harvest; traces of this fauna were shown by the brothers Schlagintweit to be present in Thibet; and also the valleys of the Indus and the Narbudda, and the Island of Perim, in the Gulf of Cambay, further Ava in the Irrawaddy basin, Burma, Java, Sumatra, the Philippines, China and Japan have yielded some sparse remains which speak in favour of an extraordinarily wide distribution of the Sivalik fauna in Southern and Eastern Asia. Through the discoveries in Persia (Maragha) and Asia-Minor (Lake Urmia, Troy), this fauna is brought in direct connection with Europe.

The so-called Sivalik fauna is not of a single independent character, for it clearly contains forms which correspond to those in the European Middle and Upper Miocene and the Older Pliocene. A distinct division into geological horizons cannot, unfortunately, at present be carried out. Nevertheless, Lydekker considers that certain localities in Sind, Cutch, on the Island of Perim, and in the Sivalik Hills specially contain older types, and others Pliocene forms. The entire fauna consists of about 150 species, which are divided amongst the following genera:—[1]

PERISSODACTYLA.
Hipparion (E.)
? *Hippodactylus.*
Equus (E.*)
? *Tapirus* (E.)
Aceratherium (E.)
Rhinoceros (E.)
(*Atelodus.*)
(*Ceratorhinus.*)
Chalicotherium (E.)

ARTIODACTYLA.
Anthracotherium (E.)
Merycopotamus.
Chœromeryx.
Hemimeryx.
Listriodon (E.)
Hippohyus.
Sus (E.)
Sanitherium.
Hyotherium (E.)
Tetraconodon.
Hippopotamus (E.)
Camelus.
Dorcatherium (E.)
Tragulus.
? *Moschus.*
Palæomeryx (E.)
Cervus (E.)
Camelopardalis (E.)
Helladotherium (E.)
Vishnutherium.
Sivatherium.
Hydaspitherium.
Bramatherium.
Alcelaphus.
Tetraceras.
? *Cobus.*
Gazella (E.)
Hippotragus.
Boselaphus.
Oreas.
Strepsiceras.
Capra.
Bucapra.
? *Ovis.*
Leptobos (E.*)
Bubalus (E.*)
Bison (E.*)
Bos (E.*)

PROBOSCIDIA.
Mastodon (E.)
Dinotherium (E.)
Elephas (E.*)

RODENTIA.
Nesokia.
Rhizomys.
Hystrix (E.)
Lepus (E.)

CARNIVORA.
(Fissipedia.)
Amphicyon (E.)
Canis (E.*)
Hyænarctos (E.)
Ursus (E.*)
Mustela (E.)
Mellivora.
Mellivorodon.
Lutra (E.)
Enhydriodon (E.)
Viverra (E.)
Lepthyæna.
Hyæna (E.)
Æluropsis.
Ælurogale.
Felis (E.)
Machairodus (E.)

PRIMATES.
Cynocephalus.
Macacus (E.*)
Semnopithecus (E.*)
Troglodytes.
Simia.

The agreement of the Sivalik fauna with that of Pikermi, Samos, Léberon, etc., in Europe, is not confined to a very considerable number of common genera but is extended even to the identity of several species. Even if a few remarkable types like *Sivatherium*, *Vishnutherium* and *Bramatherium*, are, up to the present, unknown in Europe, yet the total character of the Upper Miocene mammalian fauna in Europe, North Africa, Asia-Minor, South and East Asia is, nevertheless, so uniform, that this widely-extended region, as regards the geographical distribution of its animals, forms but one natural kingdom, to which North America may be joined as a distinct province with its own differentiated types. That the Camelidæ, otherwise indigenous to North America, also spring to the surface in the East Indies, whilst they are absent in Europe, is a remarkable fact, for, as regards the rest, Europe and North America show closer connections with each other than North America and East Asia. For a number of genera such as *Elephas*, *Bison*, *Bos*, *Bubalus*, *Leptobos*, *Equus*, *Hippopotamus*, *Canis*, *Ursus*, *Semnopithecus*, and *Macacus*, which in Europe first make their appearance in the Pliocene, Southern India may be considered as the original home, even though the Sivalik beds may not contain in places, as Lydekker supposes, genuine Pliocene forms.

---

[1] The genera marked with (E) also occur in the European Miocene; those with (E*) in the European Pliocene.

In strong contrast to the Miocene mammalian fauna spread over the entire Northern hemisphere, stand the probably contemporaneous forms of the so-called "Patagonia formation," in Patagonia and Uruguay. If one compares the following list of the genera known up to the present from these beds (from which the marine mammals, on account of their peculiar conditions of distribution, should be excluded) with those from North America, Asia, or Europe, it will be seen that their indigenous South American, or, according to Wallace's terminology, "Neotropical," character stands out not less prominently than in the older fauna of Santa Cruz.

MARSUPIALIA.
? *Notictis.*
Apera.
Cynonasua.

EDENTATA.
Gravigrada.

Promegatherium.
Interodon.
Orthotherium.
Pliomorphus.
Menilaus.
? *Gnathopsis.*
Promylodon.
Pseudolestodon.
Lestodon.
Diodomus.
Sphenotherus.
Ranculcus.
Nephotherium.
Strabosodon.

Glyptodontia.
Hoplophorus.
Palæohoplophorus.
Protoglyptodon.
Neuryurus.
Lomaphorus.
Pseudoeuryurus.

Dasypoda.
Proeuphractus.
Stenotatus.
Chlamydotherium.
? *Eutatus.*

PERISSODACTYLA.
Proterotheridæ.
Proterotherium.
Brachytherium.

Macrauchenidæ.
Scalabrinitherium.
Mesorhinus.
Oxyodontotherium.
Macrauchenia.

TOXODONTIA.
Toxodon.
? *Eutomodus.*
Xotodon.
? *Stenotephanus.*

TYPOTHERIA.
Protypotherium.

RODENTIA.
Discolomys.
Morenia.
Orthomys.
Myopotamus.
Eucardiodon.
Anchimys.
Procardiotherium.
Cardiotherium.
Plexochœrus.
Caviodon.
Lagostomus.
Megamys.
Tetrastylus.
Neoepiblema.
Euphilus.
Briaromys.
Gyriabrus.
Calpostemma.
Strophostephanus.
Paradoxomys.
Haplostropha.

CETACEA.
Pontistes.
Pontivaga.
Pontoplanodes.
Ischyrorhynchus.
Balæna.
Notiocetus.

SIRENIA.
Ribodon.

The Marsupials, Edentates, Toxodonts, Typotheridæ, as also the Perissodactyla and Rodents contained in the Patagonian (Miocene) mammalian fauna, are all of specifically South American types, elsewhere unknown. It is a more matured offspring of the Santa Cruz fauna, and is only distinguished from it by a stronger differentiation of particular genera. There is no trace of any intermixture of foreign elements which would indicate a connection with North America or with the fauna of the Northern world.

(*To be concluded in our next Number.*)

ERRATUM.—Page 409, column 1, in last number, for *Artaodactyli* read *Artiodactyla.*

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—Nottingham Meeting, September 13–21, 1893.

TITLES OF PAPERS READ BEFORE SECTION (C), GEOLOGY.

President:—J. J. H. TEALL, M.A., F.R.S., Sec. Geol. Soc.

The President's Address.

Prof. E. Hull.—Note on the Water-bearing Capacity of the New Red Sandstone of Nottinghamshire.

Prof. F. Clowes.—On a Nottingham Sandstone containing Barium Sulphate as a Cementing Material.

C. E. De Rance.—Report of the Committee on the Circulation of Underground Water.

Prof. E. Hull.—On the Discovery of a Concealed Ridge of pre-Carboniferous Rocks under the Trias of Netherseal, Lincolnshire.

J. L. Myres.—Geology of the Coast Land of Caria.

Prof. T. Rupert Jones.—Report of the Committee on the Fossil Phyllopoda of the Palæozoic Rocks.

Dr. R. H. Traquair.—On the Discovery of *Cephalaspis* in the Caithness Flags.

M. Laurie.—Report on the Eurypterid-bearing Deposits of the Pentland Hills.

Montagu Browne.—On some Vertebrate Remains not hitherto recorded from the Rhætic Beds of Britain.

George Fowler.—Note on a Fault at Cinder Hill.

Dr. H. Hicks.—On the Base of the Cambrian in Wales.

E. T. Newton.—On the Reptilia of the British Trias.

Discussion on the Limits of Geology and Geography.

Prof. J. P. Iddings.—The Dissected Volcano of Crandall Basin, Wyoming. Illustrated by Lantern Slides.

Sir A. Geikie.—On Structures in Eruptive Bosses which resemble those of Ancient Gneisses.

Prof. W. J. Sollas.—On the Pittings in Pebbles from the Trias.

Dr. V. Ball, C.B.—On Bones and Antlers of *Cervus giganteus* incised and marked by mutual attrition, while buried in Bogs or Marl.

Prof. W. H. Herdman.—Note on the exhibition of a mass of cemented shells, dredged from the sea bed.

R. D. Oldham.—Note to accompany the exhibition of a Geological Map of India.

Walcot Gibson.—Geological Sketch of Central East Africa.

Dr. H. J. Johnston-Lavis.—Report of the Committee on the Volcanic Phenomena of Vesuvius.

Dr. H. J. Johnston-Lavis.—Quartz Inclusions in Lava of Stromboli.

A. T. Metcalfe.—On the Gypsum Deposits of Nottinghamshire and Derbyshire.

O. W. Jeffs.—Report of the Committee on Geological Photographs.

H. B. Woodward.—On a Bed of Oolitic Iron Ore in the Lias of Raasay.

A. C. G. Cameron.—Note on a Transported Mass of Chalk in the Boulder Clay of Catworth, Huntingdonshire.

J. G. Goodchild.—Augen-Structure in relation to the Origin of Eruptive Rocks and Gneiss.

Prof. W. C. Brögger.—The Genetic Relations of the Basic Eruptive Rocks of Gran (Christiania region).

A. Harker.—Berthelot's Principle applied to Magmatic Concentration.

Prof. W. J. Sollas.—On the Origin of Intermediate Varieties of Igneous Rocks by Intrusion and Admixture, as observed at Barnavave, Carlingford. Illustrated by Lantern Slides.

Prof. W. J. Sollas.—On the Transformation of an Amphibolite into Quartz-Mica-Diorite. Illustrated by Lantern Slides.

W. W. Watts.—On the Hornblende-Pikrite of Greystones, co. Wicklow.

F. T. Howard and *E. W. Small.*—On some Igneous Rocks of S. Pembrokeshire, with a note on the Isle of Grassholme.

A. Smith Woodward.—Report of the Committee on the Registration of Type Specimens of Fossils.

Discussion on Coral Reefs (Fossil and Recent). Opened by *Prof. W. J. Sollas.*

Prof. C. Lapworth.—The Trias of the Midlands.

Rev. A. Irving.—Twenty Years Work on the Younger Red Rocks.

Baron von Reinach and *W. A. E. Ussher.*—Note on the exhibition of *Schizodus* and *Aucella Hausmanni* from the Magnesian Limestone of Bulwell.

Prof. E. Hull—Note on the Himlack Stone.

J. W. Gray and *P. F. Kendall.*—On the Permo-Triassic Junction at Stockport.

R. B. Newton.—Note on some Molluscan Remains lately discovered in the English Keuper.

H. Bolton.—On the Skiddaw Slates of the Isle of Man.

Prof. J. Milne.—On the Volcanic Phenomena of Japan. Illustrated by Lantern Slides.

Howard Fox.—On the Radiolarian Chert of Cornwall. Illustrated by Lantern Slides.

Discussion on Geological Education. Opened by—

Prof. G. A. J. Cole.—On Geology in Intermediate Education.

Prof. G. A. Lebour.—On Geology in Professional Education.

Prince Kropotkin.—On the Glaciation of Asia.

Prof. T. G. Bonney.—On some Assumptions in Glacial Geology.

C. A. Lindvall.—The Glacial Period, its Origin and Effects.

Dugald Bell.—Report of the Committee on the High-level Shell-bearing Deposits at Clava, Chapelhall, and other localities.

P. F. Kendall.—Report of the Committee on Erratic Blocks.

Prof. W. J. Sollas.—A Map of the Esker Systems of Ireland.

P. W. Abbott and *P. F. Kendall.*—On some Supposed Evidence of the Recent Submergence of North Wales.

Dugald Bell.—On some Shelly Clay and Gravel in the North-East of Aberdeenshire.

C. E. De Rance.—On the Pre-Glacial Form of the Ground in Lancashire and Cheshire.

Dugald Bell.—On the Granite Boulders of the Clyde Valley.

H. Arnold-Bemrose.—The Toadstones of Derbyshire. Illustrated by Lantern Slides.

Prof. W. J. Sollas.—On the Minute Structure of the Skeleton of *Monograptus priodon.* Illustrated by Lantern Slides.

W. W. Watts.—On Perlitic Structure in Quartz. Illustrated by Lantern Slides.

In other Sections—

Prof. Stirling.—Note on the Discovery of *Diprotodon* Remains in Australia.

Report of the Committee on Earth Tremors.

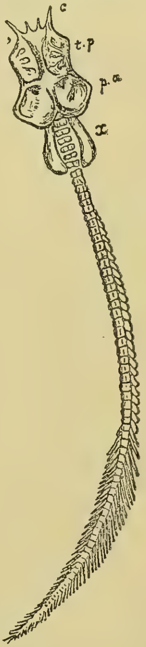
Report of the Committee on the Volcanic and Seismological Phenomena of Japan.

REVIEWS.

I.—A FURTHER DESCRIPTION OF *PALÆOSPONDYLUS GUNNI.* By Dr. R. H. TRAQUAIR, F.R.S., Proc. Roy. Phys. Soc. Edinburgh, vol. xii. 1892–93, pp. 87–94, pl. i.

THIS little organism, it will be remembered, is a supposed fossil Marsipobranch fish, first briefly described three years ago by Dr. Traquair, from the Old Red Sandstone of Achanarras, Caithness. A more detailed account of the genus and species is now given, and the author adds the accompanying restored sketch.

The organism is now shown to be destitute of jaws: and it still remains uncertain whether or not the nose was a paired organ. The supposed dorsal shield behind the head proves to consist of a pair of oblong plates, apparently not external; and between these the ring-vertebræ are spaced, while behind they form a continuous chain. There are short and stout neural spines in the abdominal region, but no ribs. No traces of paired limbs can be detected in any specimen.



Restoration of *Palæospondylus Gunni* (somewhat enlarged), by Dr. R. H. Traquair. *c.* cirri; *t. p.* anterior part of cranium; *p. a.* posterior part of cranium; *x.* paired plate-like structure behind the head.

II.—Contributions to the Tertiary Fauna of Florida. Part II. Streptodont and other Gastropods, concluded. By Dr. William H. Dall. (Trans. Wagner Free Inst. of Science of Philadelphia, Vol. III. Part II.).

THE Caloosahatchie beds, from which many of the mollusca described in this work were obtained, are the only marine Pliocene deposits of the Eastern United States of which the geological age has been admitted without controversy since they were first described. This memoir of Dr. Dall's, therefore, serves a double purpose, first to describe the unique fauna, and secondly to constitute a standard with which other Upper Tertiary beds may be compared.

The Introduction is practically a paper "On the Marine Pliocene Beds of the Carolinas," wherein the correlative value of the Floridian deposits is already manifest. In the course of his studies, the author had, necessarily, to deal with the classic faunas of the Tertiaries of North and South Carolina described by Tuomey, Holmes, Conrad, Lyell, and others. Hitherto the age of these beds has been a subject of much dispute, as to whether they are Miocene or Pliocene; up to within the past few years they have been regarded as transitional, and in 1884 received the appellation "Upper Atlantic Miocene." It has been reserved for Dr. Dall to show that the fauna is not a natural one; in other words the fauna catalogued and illustrated by Tuomey and Holmes in their "Pliocene Fossils of South Carolina" was not a true fauna at all, but a mixture of several distinct faunas, of which one was of true Miocene age, like the Virginian Miocene, whilst another might reasonably be regarded as genuine Pliocene, and the stratigraphical equivalent in South Carolina of the Caloosahatchie beds of Florida. Of course, it was not possible to accurately determine such points as these without appealing to the sections from which the fossils were derived, and this work was undertaken by Mr. Joseph Willcox, of Philadelphia, with the assistance of Mr. C. W. Johnson. The last mentioned observer carefully examined the strata along the Waccamaw river in South Carolina, and subsequently those on the Neuse river in North Carolina; and the name of Waccamaw beds is now proposed for the former, and Croatan beds for the latter, both being included in the Floridian group. The determination of the fossil mollusca obtained has enabled Dr. Dall to show that by throwing all the doubtful species into the category of extinct forms, there are from the Waccamaw beds 125 out of 180 species still found living, or about 70 per cent.; whilst from the Croatan beds there are 80 out of 96 species represented in the recent fauna, or over 83 per cent. Thus, the Pliocene age of the beds is obvious.

From these and other considerations, the author has been led to establish a new classification for the later Tertiaries of Eastern United States, as follows:—

LATER EOCENE.

Vicksburg group (Jackson, Vicksburg, and Salt Hill formations).
Ocala group (Nummulitic beds of Florida).

MIOCENE.

Chipola Epoch.

Chattahoochee group (Hawthorne and Ocheesee beds).
Tampa group (Shiloh marl, Tampa and Chipola beds).

Chesapeake Epoch.

Chesapeake group (Maryland, Virginia, etc.).
Grand Gulf group (Grand Gulf beds, Altamaha Grit, etc.).

PLIOCENE.

Floridian Epoch.

Lafayette group (Lagrange beds, Orange sand, etc.).
Floridian group (Caloosahatchie, De Sota, Waccamaw beds, etc.).

After this digression on the author's part, which may be excused on account of its exceptional interest, the shells are described, commencing with a few which in reality form a supplement to Part I. of the work. Passing by some of these we arrive at the new genus *Glyptostyla*, of which *G. panamensis*, a new species from the Miocene (?) of the Isthmus of Panama, near Colon, is the type. We do not quite see the reason for the inclusion of a Central American form in a work devoted to the Tertiary Mollusca of Florida; nevertheless it may be said that the species on which the genus is founded is extremely puzzling. "It recalls *Pyrula* by its external characters, *Turbinella* and *Mazzalina* by its solidity and heavy outer lip, *Latirus* and *Volutilithes* by its plaits."

The genus *Ptychosalpinx*, Gill, is revised, and the American species referable to it are enumerated. The author does not agree with Mr. R. B. Newton's suggestion to adopt the name *Triplex* (Humphrey) Perry, for *Pteronotus*, Swains. pre-occupied; on the ground that Humphrey's name was never illustrated or defined by him, whilst Perry's *Triplex*, is in reality a synonym of *Chicoreus*, Montfort, although he admits that possibly one of the ten species Perry illustrates may belong to *Pteronotus*—as it certainly does. The question seems to hinge on the acceptance, or otherwise, of Humphrey's work, which is not usually admitted (except when convenient) by malacologists. (By-the-bye, we notice that Dr. Dall himself has not hesitated to use a name, *Scala*, proposed by Humphrey.) For the American forms the author now uses *Pteropurpura*, Jouss.

The genus *Obeliscus* is regarded as synonymous with *Pyramidella*; and the author gives a good account of the origin (shall we say evolution?) of the name *Odontostomia*, Jeff., and gives a new scheme for the classification of the species of *Turbonilla*. He remarks, with reference to the latter, that the attempt to transfer all the plaited species to *Odontostomia* has been a failure, and that many of them will have to re-enter this genus when better known.

The reasons for separating *Seila* from *Cerithiopsis* are carefully worked out and a useful description of the soft parts of the animal of the recent *S. Adamsi* is given, which species ranges from the Miocene. *Cinctella* is referred to as a synonym of *Seila*; but *Lovenella*, Sars. (which name does not stand, however, by reason of pre-occupation), and *Læocochlis*, D. and M., are very properly regarded as distinct from that genus.

Some very suggestive observations are made under *Cerithium*, which deserve to be made more widely known. The author remarks, and we think pertinently, that the sub-divisions into which the genus has been split up are worthy of more extended comparative study than they have hitherto received, but unfortunately does not attempt to enter much into detail in regard to the matter, for reasons that are sufficiently obvious, in a special work of the kind under review. He states, however, that in sorting over large numbers of specimens of one species, either recent or fossil, it will be noticed that there are two sets as it were, otherwise similar, one much more slender than the other. We can quite bear out this observation in regard to many European Tertiary fossils belonging to the group. This, he says, may be a sexual difference; it is observable in *Bittium* and *Seila* also. "The principal variations of the species are; 1st, size, there being in almost any large lot a few or possibly many dwarfs, otherwise similar—recalling the difference of size in *Cypræa*; 2nd, in the intensification of (*a*) the transverse, wavy sculpture, which, in any species which has it, may be strong, weak, or wholly absent; (*b*) the nodulations or tessellations of the primary spiral bands or revolving ridges, which vary in the same species from obsolete to very sharp and prominent; (*c*) the prominence of the primary bands, which is very variable, apart from the nodules they may bear. The secondary fine striation, as in *Buccinum*, is much more constant in its features than the coarser sculpture."

The only reservation we would make to this is, that unless in possession of very ample materials the palæontologist would have some difficulty in determining how far the variations recorded might be regarded as of specific value; whilst it is certain that what might be called a mere deviation from the type in some very variable species would in others, usually more stable, be looked upon as characters having a higher importance. It has been remarked that the scarcity of Cerites is characteristic of the American Tertiary, but our author thinks that this is due rather to ignorance of the fauna than to anything else, and he makes substantial additions in the present paper to the number of species of *Cerithium* hitherto known to occur in the United States.

The author has given considerable attention to *Turritella*, which in some respects is a most unsatisfactory genus to deal with. In speaking of *T. subannulata*, Heilp., he refers at some length to the variation which that species exhibits, and states that some people would find fifty or sixty "species" amongst the material in which he can only see one. There is much wholesome criticism in the general tendency of this remark, but at the same time we should be careful to make it apply all round. Given "enough material" it should be possible to trace gradations from most of the "species" of a genus, through space and in time, to one another. We quite sympathize with the author in his difficulties where a mass of material is available, yet it seems to us to be quite as convenient to give a "specific" name to the extreme types of variation as to further burden the forms by adding a varietal cognomen—no one, in the present state of our knowledge as to the value of a molluscan "species," is likely to be deceived thereby. The case at present stands thus:—If you have, say, four shells which can be readily distinguished from one another and exhibit a certain amount of striking difference, they would be called four "species," without hesitation; if, however, "enough material" be subsequently obtained and forms are found linking these four together, they would be regarded as one species only, but by way of compensation for the degradation thus sustained they would, perhaps, receive varietal names.

We are not going to defend the "nouvelle école" to which Dr. Dall applies some well-merited strictures, on account of its "hair splitting" propensities; but it may be pointed out that if fig. 4 of plate xvi. of the work under review is to be regarded as the same species as that depicted on the same plate, fig. 1, viz. *Turritella subannulata*, then fig. 4 (var. *acropora*, Dall) and the whole of the forms included thereunder ought to be rigorously compared with *T. acutangula*, Brocc. (syn. *T. subangulata*, Brocc.), of the Southern European Miocene and Pliocene. The gaps existing between the American and the European species alluded to are very slight, and could easily be bridged over. We possess specimens of both species, and some of the latter which we have from the Miocene of Pontlevoy (near Tours) are practically identical with the var. *acropora*. It would not be difficult to multiply examples of this kind, but we content ourselves with the foregoing for the present.

This seems a fitting opportunity to remark on the ornate appearance of many of the North American Tertiary *Turritellæ*; we have observed that wherever this genus is very abundant in the fossil state in Europe it is usually more ornate than where it is sparsely represented, especially as far as the Pliocene is concerned. But we have nothing on this side to compare with Heilprin's *T. perattenuata* from the Floridian Pliocene; amongst other things it attains a length of 135·0 mm. with a maximum diameter at base of 13·5 mm. and exhibits no less than 44 whorls! Specimens of *T. apicalis*, Heilp., in our possession have 23 and 24 whorls respectively.

The genus *Solarium* comes in for a good share of attention. Dr. Dall remarks that it occurs abundantly in the American Eocene, but has been generally misunderstood, the small Trochoid pearly shells properly called *Solariella* having in the United States, as in Europe, been frequently described under the name of *Solarium*, which latter is never pearly, and belongs to a wholly diverse line of development. The examination of the fossil species has led our author to subdivide the genus into sections. He remarks that the form of the shell in most of the groups may vary by having—(1) the whorls rounded at the periphery; or (2) the periphery keeled; or (3) with a shallow, wide sulcus on the top or base of the whorl near the periphery; or (4) by having the spiral sculpture simple or granular along the threads. The following are the sections of *Solarium* proposed: (1) *Solarium, sensu stricto,* Type *S. perspectivum,* Lamk.; (2) *Solariaxis,* Type *S. elaboratum,* Conrad; (3) *Patulaxis,* Type *S. scrobiculatum,* Conrad; and (4) *Stellaxis,* Type *S. alveatum,* Conrad.

Passing to the genus *Calyptræa* we may notice that *C. trochiformis,* Lamk., has to give way to the earlier *C. aperta,* Sol., with which it is synonymous. It is noteworthy that a form so characteristic of the European Eocene as *C. aperta,* should be found not only in the Lower Tertiary of Claiborne and Vicksburg but ranging up into the newer Miocene of the United States. When the Tertiary molluscan faunas of both sides of the North Atlantic have been rigorously compared—especially the Eocene—we have no doubt that many more forms than have hitherto been discovered will be found to be common to each continent.

When we reach *Crepidula,* Lamk., 1799, we find that the author adopts this name instead of *Crypta,* Humphrey, 1797, which is thus anterior, on the ground that the last-mentioned author's name was proposed "in an auction catalogue, without figure, diagnosis, or reference to literature," and we quite agree with this decision; yet in another part of the work we see that the name *Ampullinopsis,* Conrad, 1865, is retained as a section of *Ampullina,* and *Megatylotus,* Fischer, 1885, is cited in the synonymy, in spite of the circumstance that Conrad's name was never defined, whilst that of Fischer is properly established—a fact of which the author appears to be perfectly cognizant. He complains that M. Cossmann has omitted to state the occurrence of *Megatylotus crassatinus,* Lamk., in his monograph on the Paris basin—we may observe that the French author alluded to confined his attention in that work to the fossils from the Eocene—the species will be found duly recorded in its proper place in his later Oligocene monograph.

In regard to *Dentalium,* Dr. Dall remarks that although Stoliczka has divided the group into a number of genera and two sub-families, he suspects that the differences upon which they are chiefly based, such as the supposed forms of the foot in *Siphonodentalium* and *Dentalium* proper, are less important than might be supposed from the few published figures, and require further investigation before they can be safely used in systematic work. He therefore retains the old nomenclature for the present. As it is impossible to discriminate, in dealing with fossil species, between those belonging to *Cadulus* and *Siphonodentalium,* he refers all the forms treated of to the former genus, and cites *Gadus* in the synonymy.

The work is accompanied by an excellent geological map of Florida, by Dr. Dall, which is reproduced, by permission, from Bulletin No. 84 of the United States Geological Survey, in which our author fully discusses what is known of the geology of the State.

The importance of this work to students of the mollusca cannot be overrated. It is true that here and there a few blemishes occur, as was inevitable in a book of such magnitude. The principal fault we have to find is that the author's title is too restrictive

—too modest. A large number of forms found outside Florida are figured and described. In many respects Dr. Dall's work may be regarded as a species of text-book on the Tertiary Mollusca of the United States, having especial reference to Florida. In several instances all the known fossils of a genus occurring in America are alluded to under the description of that genus; and a good deal of critical revision is effected in almost every branch. It is the work of a thorough master of the subject, and we look forward with considerable interest to the appearance of Part III. in which the author hopes to begin and conclude the description of the bivalves, and to give a general summary and tables. G. F. H.

CORRESPONDENCE.

THE PEBBLE-RIDGE AT WESTWARD HO.

Sir,—The Pebble Ridge at Westward Ho has often been noticed by geologists, and was the subject of a paper by Mr. Pengelly, F.R.S., so long ago as 1868.[1] During a recent visit my attention was attracted to a peculiarity in the "pebbles," which, although not referred to by Mr. Pengelly, can scarcely have escaped observation. So far as I am aware, however, the said peculiarity has not been recorded. The feature referred to is the concentric lamination often induced in "pebbles" above a few inches in diameter. An outside coat about $\frac{1}{16}$ of an inch in thickness peels off, and often underneath the first a second layer comes away. Thus the "pebbles" exhibit all the appearance of a concentric concretionary structure. But as the "pebbles" can be traced to their origin in rhomboidal or rectangular blocks of the local grits, the concentric structure, following the varying curves of the rounded "pebbles," must necessarily be induced and not original. Although this structure is very common I could not find a single instance in a "pebble" sufficiently small and light to carry away in my pocket. It is confined entirely to weighty stones. It would almost seem as though we had in these rounded "pebbles" a sort of pseudo-concentric cleavage caused by percussion, and if so we may possibly find in these "pebbles" a clue to the concentric concretionary structure often noticed by geologists, and which in certain cases may be due not so much to crystallization as to pressure acting equably on the surface of a nodule enclosed in softer strata. However, my object in writing is to call attention to a significant fact rather than to attempt to explain it. A. R. Hunt.

Torquay.

THE RELATIVE AGE OF FLINTS.

Sir,—I have to thank Mr. Jukes-Browne for his article on the Relative Age of Flints in your July issue. His paper is a valuable contribution, and will materially assist the workers in this most difficult subject by directing their attention to those points which most require elucidation.

I gather that, as regards tabular flint, he believes it was formed in fissures, and that microscopically it has the same appearance as flint from the Nodular layers. At present I must confess to being ignorant of his reason for putting flint floors in a separate classification. Is it simply their wide extent? True, they are generally quite solid and free from the cavities so common in the more vertical sheets of flint, but this, I had supposed, was due merely to the horizontal position favouring the deposit of silica because of the slower current of water.

---

[1] Trans. Dev. Assoc. 1868, p. 415.

These horizontal layers, whatever their origin, show, with this exception, the same signs as the others of having been formed originally of two plates, and probably in open joint-planes. Should Mr. Jukes-Browne's suggestion that the flint was deposited in cracks during the first upheaval of the chalk be correct, we must believe that these cracks often extended at least through 100 ft. of soft chalk saturated with sea-water, and that many of these fissures were far from being vertical, frequently at an angle of only 30° with the horizon.

My suggested explanation of the absence of flint in the Lower Chalk only referred to the beds in our S.E. district, and I take it that Mr. Jukes-Browne's experience does not refute my belief that wherever there are nodules in the Lower Chalk they are also present in the Upper Chalk, but not *vice versa.* He is doubtless aware that it has been asserted that the total percentage of flint in different beds is roughly the same. If this be true, surely we must look to segregation as the cause of all the visible flint in the cretaceous strata, and the question is, when did this process take place?

The varying character of flints in successive zones is doubtless of importance, but does not prove that flint was contemporaneous with the chalk; though evidence of the traces of the *soft* parts of organisms in flint would probably be conclusive, and I should be glad to hear if such have been found.

The cores I spoke of are not tubular, and I still fancy are not formed round Doryderma, though probably confined to one particular zone. The outer coats of these flints are generally shaped like a potato, hollow inside, with a solid cylindrical core passing through from end to end. This is the simplest form, but sometimes other cores cross the first at various angles. I should be glad to submit specimens to Mr. Jukes-Browne if he would care to see them.

These cores, as well as some other flints I have, containing remarkable loose kernels, lead me to ask him to allow me to add "Mechanical Flints" to his classification, and to include concentric circles of flint with his Paramoudra division.

I can only briefly touch on the chemical influences involved, except that I doubt that Mr. Jukes-Browne's theory of the precipitation of silica through contact with carbonated water can be accepted; but his paper was all too short, and I should be glad if in some future communication he would give us his views as to the sources whence the large quantity of silica for Flint-floors, etc., was derived. George Abbott, M.R.C.S.

Tunbridge Wells, *Aug.* 1, 1893.

OBITUARY.

DAVID HOMFRAY.

Born June 21, 1822. Died June 22, 1893.

Through the death of Mr. David Homfray, of Portmadoc, we have been deprived of one of the pioneers of Geology in North Wales. When but a mere youth Mr. Homfray left his home, Witley Lodge, near Hales Owen, Warwickshire, for Portmadoc, where his uncle, who was Manager of the Welsh Slate (Palmerston's) Quarry at Ffestiniog, resided. He took to the law, and was for many years, up to the time of his death, Clerk to the Justices of the Peace for the Penrhyndendraeth Division.

Prof. Sedgwick says that North Wales, when he entered it in 1831, "was little more than *terra incognita*," and it was not until after 1857 that Mr. Salter determined by their suite of fossils that the Tremadoc Rocks deserved to be ranked as a separate formation. These fossils were, to a very large extent, collected by Mr. Homfray, as, shortly after 1850, we find him, encouraged by Salter, employing his leisure in working the Portmadoc district, where, especially in the Tremadoc rocks, he discovered many new forms, several of which were named by Salter in honour of him, e.g. *Niobe Homfrayi*, *Asaphus Homfrayi*, *Conularia Homfrayi*, etc. As early as 1859 he presented to the Privy Council on Education a series of Trilobites, etc., illustrative of the Geology of the Lingula Flags of Portmadoc.

At Mr. Salter's request he searched for, and worked, the Menevian-beds of the Maentwrog Waterfall Valley, which beds were then only known at St. Davids through the labours of Dr. Hicks, F.R.S., and Mr. Salter. Here Mr. Homfray met with his usual good success, which led Salter to say of him: "He can find anything he likes in his territory." At Maentwrog he discovered for the first time in Britain, *Conocoryphe coronata*, Barr., and *Conocoryphe Homfrayi*, Salt. Having made an exhaustive study of the rocks of his own district, he visited Dr. Hicks' ground at St. Davids in 1872, and with Dr. Hicks and others worked at the Tremadoc rocks of Ramsay Island. He again visited St. Davids in Dr. Hicks' company in 1874. He spent a considerable portion of the summer of 1875 in accompanying Professors Ramsay and Etheridge, and Mr. Ward, in mapping the Garth Grit, and otherwise revising the Geology of North Wales. The numerous references to Mr. Homfray's labours, and quotations of his opinions in Ramsay's "Geology of North Wales," prove what a high opinion the latter entertained of him.

It is seldom that we meet with a geologist who has toiled so hard, and amassed such a store of valuable information, but has never published an article on his favourite subject. Such, however, was the case with Mr. Homfray. He was content with supplying information to others, which he always did most readily. The same generosity characterized him in giving away his specimens, for he not only gave away his duplicates, but often the only specimen he possessed of a rare species.

When he made a present to the Woodwardian Museum in 1869, Salter writes: "Sedgwick is so pleased, his face quite glowed," and Sedgwick himself writes: "Most sincerely do I thank you for your kind letter, and for so kindly allowing us to select from the specimens what we think most important to our Museum. At the same time, I feel a difficulty in accepting (not of course on my own account, but on that of the University) some of your specimens, which are of inestimable value; the grand, almost perfect specimen, of *Paradoxides* is (so far as I know) unrivalled and above comparison." In October, 1872, after another consignment, Sedgwick writes: "In the number and value of the fossils you sent us you stand foremost in our list." Many of Mr. Homfray's fine specimens may also be seen in the British Museum (Natural History), and in the Owen's College Museum, Manchester.

Though he could in later years hardly keep pace with the advance of Geological Science, he took the keenest interest in it up to the time of his death, and gave, as the writer can testify from experience, every encouragement to younger lovers of his favourite science. In addition to being a Geologist, he was also an enthusiastic Botanist, and a devoted student of Natural History in general.

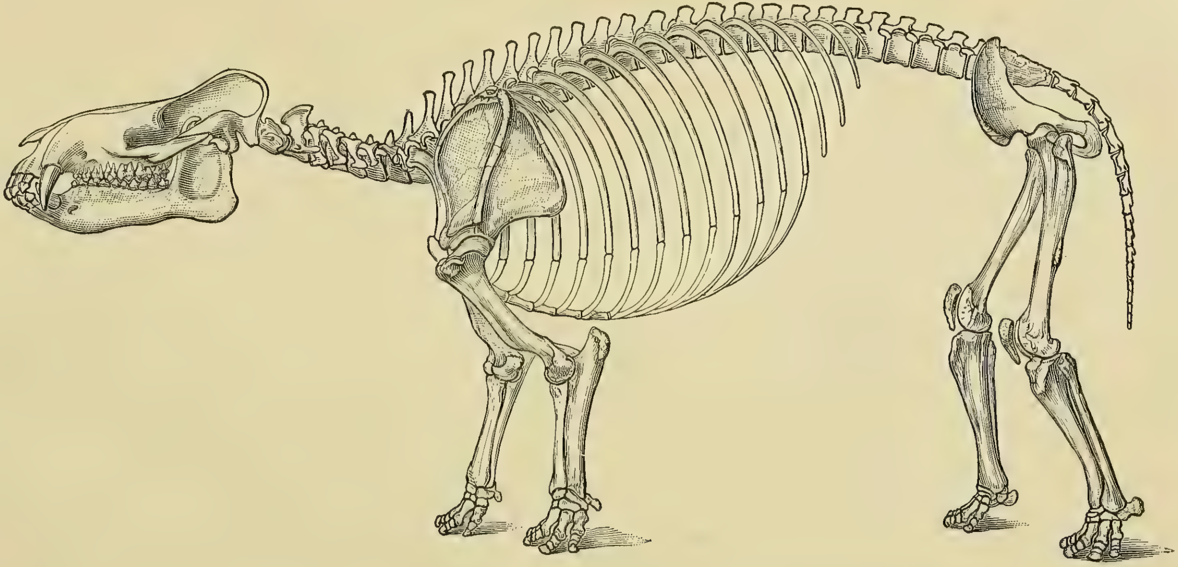
Dr. Hicks, who kindly read over these notes, says: "I can endorse every word you say in regard to the generous and estimable friend whose death we all lament. His keen eye, combined with shrewd observation and a highly sympathetic nature, has rendered invaluable service to Cambrian geology, and can only be realized by those whose pleasure it was to be with him in the field. When Salter and I were working on the Menevian rocks, now nearly thirty years ago, dear David Homfray was the first to offer assistance, and to be ready to join us in our explorations. I can never forget what we owe to his enthusiasm and to his delightful companionship. He was in truth a typical scientific man, who loved truth for truth's sake only, and cared little for the honour which it brought."

Mr. Homfray bore a painful illness with great courage; and by those who knew nothing of his geological labours he will long be remembered, as he was described in a local magazine, "a strict, upright, generous, charitable, and hospitable Christian gentleman."

G. J. Williams.

GEORGE WILLIAM SHRUBSOLE, F.G.S.

This well-known local geologist was born about 1827–28, and belonged to the Kentish family of the same name. He settled in Chester some forty years ago as assistant to a chemist, and in the course of a few years opened an establishment of his own in Market Square, which is still in the hands of his sons. Mr. Shrubsole was the Honorary Curator of the Grosvenor Museum, was an enthusiastic geologist, botanist, and antiquary, and was one of the founders, with Charles Kingsley, of the Chester Society of Natural Science. Mr. Shrubsole's health began to break in 1891, and although he submitted to an operation and was restored for a time, complications arose six weeks before his death, which occurred on the 22nd July, 1893.



Restoration of CORYPHODON HAMATUS, Marsh. One-twelfth natural size.

From the Coryphodon beds,—Lower Eocene,—Wyoming, United States.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. X.

No. XI.—NOVEMBER, 1893.

ORIGINAL ARTICLES.

I.—Restoration of *Coryphodon*.

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S., Etc.

(PLATE XVIII.)

THE genus *Coryphodon*, established by Owen in 1846, is of great importance alike to geologists and palæontologists. It represents a remarkable group of large ungulate mammals now known to have lived both in America and Europe during early Eocene time. The remains are found in a distinct horizon, essentially the same in each continent. This horizon is so well marked that geologists may use it as a base for determining the age of other strata. The Coryphodont mammals themselves are of special interest to anatomists, owing to the primitive characters shown in the skeleton. Perhaps their greatest importance lies in the fact, that these large hoofed mammals make their appearance suddenly in great numbers at the base of the Tertiary, without a hint as to their ancestral line, and with only diminutive generalized forms for their Mesozoic predecessors.

In Europe, Coryphodont remains, especially teeth, have been known under various names since the time of Cuvier, the first specimen, a molar tooth, having been found in 1807. All the remains since discovered there have likewise been fragmentary, and descriptions of them will be found in the works of Owen, Hébert, de Blainville, and more recent authors. A summary of the literature is given in the Palæontology of von Zittel, Volume IV. now in the press.

The first specimen of *Coryphodon* discovered in America was found in 1871, near Evanstone, Wyoming, by William Cleburne, while engaged as surveyor for the Union Pacific Railroad. He secured various remains, chiefly teeth and vertebræ, which were found together, and apparently belonged to a single individual. Some of these specimens he gave the same year to Prof. F. V. Hayden for transmission to Dr Joseph Leidy, who failed to receive them. They were subsequently described by Prof. E. D. Cope under the new generic names *Bathmodon* and *Loxolophodon*.[1] Portions of the same skeleton, including both teeth and vertebræ, were later given to the writer by Mr. Cleburne, and with them the above statement of the discovery and disposition of the specimens found. Prof. Cope, in 1872, gave the name *Metalophon* to a specimen from another locality in Wyoming, and subsequently (1873–1875), in several papers, and under the above generic names, described various remains from Wyoming and New Mexico. He also gave figures of a molar tooth, the hind foot, and a skull, all of which he referred to his genus *Bathmodon.*

---

[1] Proc. Amer. Philos. Soc. vol. xii. pp. 417 and 420, 1872.

In the meantime, the writer had been investigating remains of the same group from Wyoming and New Mexico, including portions of the original specimen found by Mr. Cleburne, and other material of much interest. It was soon ascertained (1) that all these remains were apparently identical with those of the genus *Coryphodon*, Owen, as described and figured by him and Hébert;[1] and (2) that the geological horizon of these fossils was essentially the same both in America and Europe. An investigation was made of the skull, and especially of its brain-cavity, the latter indicating a brain of very inferior type. The feet proved to be of a primitive form, the manus and pes each having five very short functional digits. The remains studied belonged to a new family, named by the writer the *Coryphodontidæ.* These and other results were brought together in a paper entitled "On some Characters of the genus *Coryphodon*, Owen," and in it were given figures of the skull and the brain-cavity of a new species, *Coryphodon hamatus.* This paper was published separately, April 15th, 1876, and subsequently appeared in the American Journal of Science, vol. xi. p. 425, May, 1876.

Subsequent to the publication of these determinations by the writer, Prof. Cope admitted, in several papers, the reference of these remains to the genus *Coryphodon*, and the identity of the horizons in this country and Europe in which they were found, but without referring to the above article on the subject. He likewise described in detail, and figured, in 1877, what he considered a brain-cast of *Coryphodon*, but again without any reference to the paper in which, the year before, the writer had given accurate figures of the brain-cast of that genus. In the specimen described by Prof. Cope, the cribriform plates of the brain-case were apparently wanting, so that in the cast figured the olfactory lobes appear to extend far forward, thus giving a wrong idea of the original brain.[2]

In the same year, 1877, the writer published a second article under the title, "Principal Characters of the *Coryphodontidæ*," in which he gave more in detail a description of the skull and brain-cast of *Coryphodon*, with a figure, and also the main facts in regard to the skeleton. The feet of this genus, before practically unknown, were described and figured, and especially compared with those of *Dinoceras*, which were also represented for comparison.[3] In Woodcut, Figs. 2 and 3, of the present article, the original figures of the feet of

---

[1] British Fossil Mammals and Birds, p. 299, 1846; and Annales des Sciences Naturelles, tome vi. p. 87, 1856.

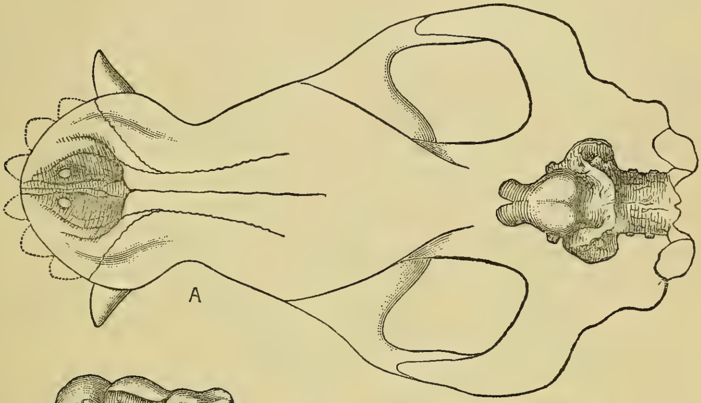
[2] Proc. Amer. Philos. Soc. vol. xvi. p. 616, plates i–ii. 1877. See also Amer. Naturalist, vol. xi. p. 312, and 375, 1877; and Nature, vol. xvii. p. 340, 1878.

[3] American Journal, vol. xiv. p. 81, plate iv. July, 1877.

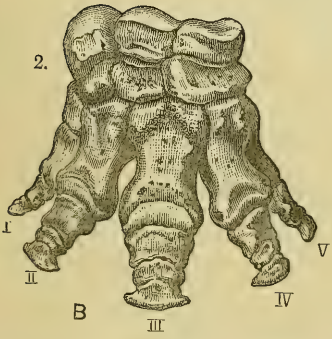
Coryphodon, as given by the writer in 1877, are repeated. The original figure, also, of the skull and the brain-cast, given by the writer first in 1876, and again in 1877, is repeated below, Figure 1.

In another publication (American Journal, vol. xiv. p. 354, 1877) the writer defined more fully the horizon in the lower Eocene in which the *Coryphodontidæ* had been found in this country, and named the deposits the Coryphodon beds.

1.



2.



3.

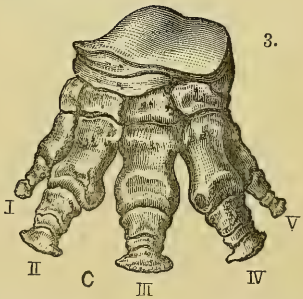


Fig. 1.—Outline of skull and brain-cavity of *Coryphodon hamatus*, Marsh; top view. About one-fifth natural size.

Fig. 2.—Fore foot of *Coryphodon*; front view.

Fig. 3.—Hind foot of *Coryphodon*; front view. Both one-third natural size.

The most important publication of Prof. Cope on the *Coryphodontidæ* will be found in vol. iv. of the Wheeler Survey, published in 1877. The remains of a number of different forms, mainly from New Mexico, are described and figured, and the relations of the group to some allied mammals are discussed. In the following year, Prof. Owen published again on *Coryphodon*, in the Annals and Magazine of Natural History (vol. ii. p. 216, 1878), giving figures of some American forms. In various papers, Prof. Cope subsequently referred to the *Coryphodontidæ*, naming several supposed species and two genera, *Manteodon* and *Ectacodon*, but adding little of importance to what was already known of the group. In his volume on "The Vertebrata of the Tertiary Formations of the West," 1884, he again discusses at length the *Coryphodontidæ*, and gives a number of new figures. The historical part, pp. 513–517, is marred by many errors, characteristic examples of which may be seen in two footnotes, pp. 513 and 516. The statements there made are erroneous, as has already been shown in the present article.

In his monograph on the *Dinocerata*, 1884, the writer discussed the various relations of the *Coryphodontidæ* to the *Dinocerata*, giving figures of the skull and brain-cast, the upper and lower molar teeth, and the feet, of *Coryphodon hamatus*. The name *Amblydactyla* was substituted for *Amblypoda*, and *Coryphodontia* for *Pantodonta*, the names replaced both being essentially preoccupied.

Two recent papers by Mr. Charles Earle, on the *Coryphodontidæ*, are of interest.[1] He treats of the teeth of this group, especially of their variations and homologies, and gives figures of some of the most characteristic forms. He also discusses at length the various American species named, and decides "that the large number of species which have been founded by Prof. Cope should be greatly reduced; and that in many cases his species are to be considered merely varieties, and that often these varieties are merely individual variations in the same species due to age and sex."

In a joint paper by Prof. H. F. Osborn and Dr. J. L. Wortman, which appears in the Bulletin of the American Museum, p. 81, 1892, the former discusses this group briefly, especially some specimens recently collected in the Wind River region by Dr. Wortman, and gives two figures of the feet of *Coryphodon*. In this paper, p. 118, the family *Coryphodontidæ*, established by the writer in 1876, is credited to Prof. Cope, but with no reference as authority, while the preoccupied names *Pantodonta* and *Amblypoda* are also used in place of *Coryphodontia* and *Amblydactyla*.

In discussing the foot structure of *Coryphodon* (p. 121), Prof. Osborn makes some very emphatic statements, which are important if true, but he gives no facts to support them, and there is good evidence that he is in error. One statement is as follows: "the positions of the fore and hind feet of *Coryphodon* were absolutely different, the *fore foot was digitigrade* like that of the Elephant, and the *hind foot was plantigrade* like that of the Bear." These positions are shown in his figures, which afford no evidence to support the statement, especially in regard to the hind foot. Again, in giving the characters of the feet, Prof. Osborn adds to what was already known, that the "second metacarpal" has a vertical ectocuneiform facet; a statement likewise open to question. Another assertion (p. 122) nearly as strange is, that in "The figure of the pes of *Coryphodon* given by Marsh . . . . the astragalus is represented as *covering the entire upper surface of the cuboid.*" A reference to the figure in question (fig. 3) will, however, show this statement, also, to be wrong, as the calcaneum covers about half the cuboid." This fact was clearly stated in the text when the figure was first published. The "unique caudal appendage" described by Prof. Osborn (p. 120), and the suggestion in regard to its use, do not require special notice here. The above points will be discussed later in the present article.

---

[1] Science, vol. xx. p. 7, 1892; and Bull. Amer. Mus. vol. iv. p. 149, 1892.

Restoration of Coryphodon hamatus.

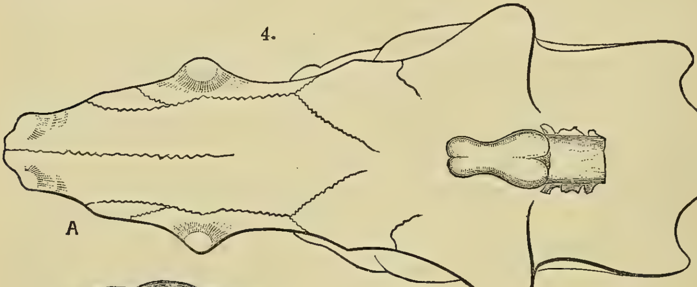
After the above brief review of the more important literature relating to the Coryphodont mammals found in America, the main object of the present article, the restoration of one species of *Coryphodon*, may be considered. In Plate XVIII. this restoration is given one-twelfth natural size. The position shown was chosen after careful consideration, and is believed to represent fairly one naturally assumed by the animal in life, when standing at rest. The figure represents a fully adult individual of one of the largest species of the genus, which, when alive, was nearly six feet in length, and about three feet in height.

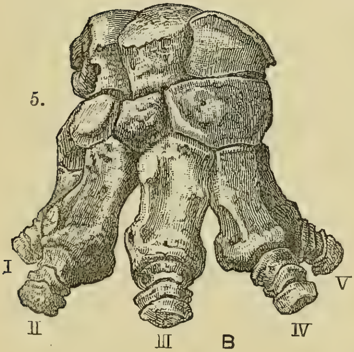
The basis of this restoration is the type specimen of *Coryphodon hamatus*, and this was supplemented by other remains which appeared to be specifically identical. A large number of such specimens were available, some of them in excellent preservation. For parts of the skeleton where such remains were wanting, specimens from nearly allied forms were used, but no serious error can thus result. In these remains, the caudal vertebræ were seldom preserved in good condition, and although a sufficient number of such specimens from different individuals were at hand, the exact number in the present species could not be determined, and hence the vertebræ of the tail are left in outline.

No clavicles are represented in the restoration, and no evidence of their existence has been found by the writer in the many remains investigated. The specimens described by Prof. Cope as clavicles of *Coryphodon* probably do not pertain to that genus. A bone very similar in shape to the supposed clavicles was figured by him as the fifth metatarsal, in the first diagram he published of the hind foot of *Coryphodon*. The same figure has three phalanges in the first digit, and the ectocuneiform supported mainly by the astragalus; features not seen elsewhere by the writer.

The feet of Coryphodon.

The structure and position of the feet of *Coryphodon*, as represented in the restoration, require some consideration in this connection, in view of differing opinions on these points. The fore feet of *Coryphodon* were first figured and described by the writer, and figure 2 is the original cut then published. This figure was made from a well-preserved specimen in which both fore feet were present, and nearly in position when found. They were carefully kept in the matrix until prepared for the drawing, and hence the accuracy of the figure cannot well be questioned. The fore feet represented in the present restoration are constructed mainly from the same specimen, and the position given in the original figure has been essentially retained. The small size of the restoration does not permit as accurate an exhibition of the structure of the feet as could be desired, but the main features are clearly shown. In this species, the pyramidal bone (cuneiform) touches the fifth metacarpal, and helps to support it, as in *Dinoceras*, as already shown by the writer. This is the rule in adult individuals of *Coryphodon*, but in young specimens the metacarpal facet on the pyramidal may be indistinct or even wanting, as is sometimes the case with weathered specimens.





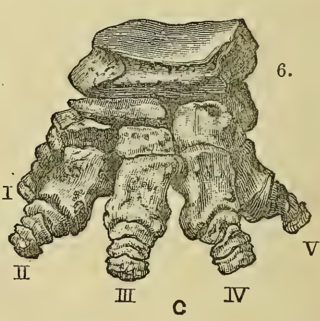
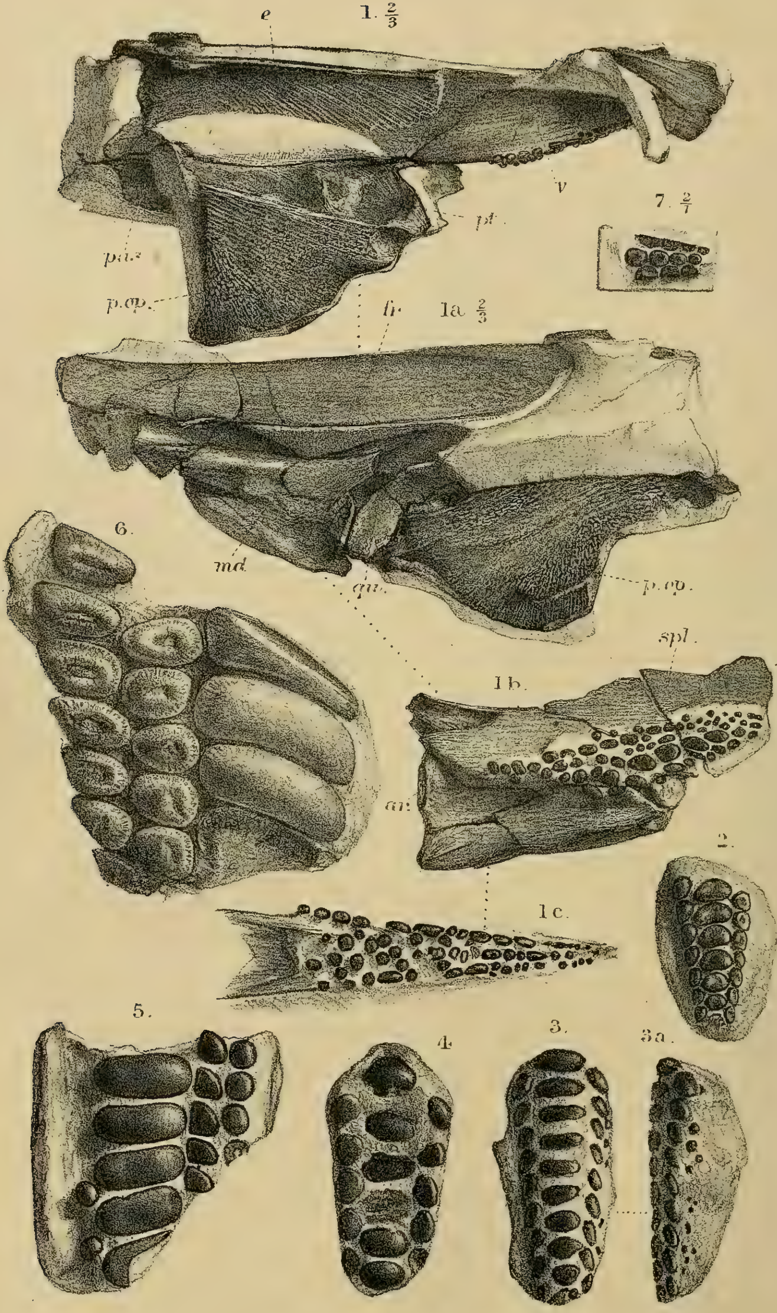


Fig. 4.—A. Frontal aspect of cranium of *Dinoceras* (Marsh).
Fig. 5.—Fore foot of *Dinoceras*; front view.
Fig. 6.—Hind foot of *Dinoceras*; front view. Both one-fifth natural size.

The hind feet of *Coryphodon* were investigated by the writer at the same time as the fore feet, and figure 3, of the left pes, was published with figure 2, and is believed to be equally accurate. Being a front view, it does not fully show the relations to each other of the astragalus, calcaneum, and cuboid, but the other elements are clearly exhibited. The position first given to the figure is retained in the restoration after a careful investigation of the whole posterior limbs in a number of well-preserved specimens. These differ considerably among themselves, but the essential structure is identical in all. The feet bones of some of these specimens are very perfect, and their relations to each other cannot well be misinterpreted.

Geol. Mag. 1893. Decade III. Vol. X. Pl. XVII.



F.H. Michael del. et lith.

Mintern Bros. imp.

CRETACEOUS PYCNODONTS.

The above figures show the left fore and hind feet of *Coryphodon* and *Dinoceras* all seen from in front. The feet of the two genera as exhibited have many points in common, and their positions during life were probably nearly the same. The feet of *Coryphodon* are older in point of time. Those of *Dinoceras* are near to *Coryphodon* in their general structure, but the points of resemblance need not be enumerated here.

The existing Elephant, as well known, has all the toes of each foot enclosed in a common integument, but is really digitigrade. In *Dinoceras*, the terminal phalanges are much larger, showing that they themselves bore a greater weight, the digits being undoubtedly free, although a pad may have helped to support the foot. In *Coryphodon*, the digits were still more elongate, and the terminal halanges proportionately larger and broader, somewhat like those of the Rhinoceros, indicating that they were covered with hoofs that supported the feet. This would agree with the position given them in the restoration, which coincides with the anatomical structure of the entire hind limb.

II.—Some Cretaceous Pycnodont Fishes.

By A. Smith Woodward, F.L.S., F.G.S.

(*Continued from page* 436.)

2.—On the Genus *Anomœodus*, with Remarks on the Structure of the Pycnodont Skull.

(PLATE XVII.)

THE only important fragment of a Pycnodont fish hitherto known from the English Cretaceous Formations, is the portion of head and trunk figured and briefly noticed by Dixon under the name of *Gyrodus angustus*, Ag.[1] This specimen displays the splenial bones from the oral aspect; some of the vertebral hæmapophyses; and thick scales with a reticulated ornament, covering only the anterior half of the trunk. The ventral ridge-scales also exhibit very conspicuous serrations. The splenial bones are imperfect, but sufficient to show all the essential characters of their oral face; and these elements present the only unique feature in the specimen. It will be observed that, whereas in all Pycnodont splenials hitherto described the dentition reaches the outer border at least in part of its extent, the bone in *Gyrodus angustus* has a wide toothless outer margin and an attenuated knife-like edge. The two vacuities in this margin shown in Dixon's figure are partly due to accident, partly imaginary, and there is no doubt that the bone forms a continuous whole.

Now, it is obvious from the specimen just described, that the fish in question cannot be assigned to the genus *Gyrodus*; for it differs both in the arrangement of the teeth and in the absence of scales upon the caudal region. It has thus been suggested[1] that the species might be more appropriately placed in the typically-Cretaceous genus *Cœlodus*; and at the same time it has been recognized that there is no essential generic difference between the form of dentition known as "*Gyrodus angustus*" and that from Maastricht, described by Agassiz, under the name of *Pycnodus subclavatus*. No splenial bones of the latter have hitherto been discovered sufficiently well preserved to show whether or not they possess the toothless border so characteristic of the species from Sussex; but if any reliance can be placed upon the agreement in the arrangement of the teeth the generic identity of the species *G. angustus* and *P. subclavatus* may be determined with as much certainty as can be attained in the classification of fragmentary Pycnodont remains.

---

[1] F. Dixon, "Geology and Fossils of Sussex" (1850), p. 370, pl. xxxiii. fig. 1. See also Smith Woodward, Proc. Geol. Assoc. vol. x. (1888), p. 307.

To decide upon the accuracy of this identification or otherwise is important, because six years ago the dentition commonly known as *Pycnodus subclavatus* was described by Forir[2] as indicating a previously unrecognized distinct genus, *Anomœodus*; and the sole definition was based upon the arrangement of the splenial teeth. If, now, the universal belief that "*Gyrodus angustus*" and "*Pycnodus subclavatus*" are generically identical, be correct, new evidence is forthcoming to render the definition more satisfactory. So far as the arrangement of the splenial teeth in *Anomœodus* is concerned, there is no essential point to distinguish it from the Jurassic genus *Mesodon*; but on examining the attached face of the bone (e.g. *A. superbus*, Pl. XVI. Fig. 5*a*), the form will be seen to be quite different from that of *Mesodon* (Pl. XVI. Fig. 6), the first being shaped as in *Pycnodus* with a single sharp ridge curving to the postero-external angle, the second having a broad, longitudinally-grooved ridge not so sharply turned outwards. As regards the comparison with *Cœlodus*, it may be remarked that the difference in the arrangement of the splenial teeth is too great to render generic identity probable.

We therefore assume that the provisional arrangement adopted by Forir will eventually prove correct, and that the characters of the splenial bone, now known only in two British Cretaceous species, will be shown by later discoveries to be common to the others. On this assumption the following preliminary diagnosis may be hazarded:—

Genus ANOMŒODUS.

Head-bones ornamented with reticulating rugæ; the smaller teeth usually with an apical indent, the principal teeth quite smooth or with a very feeble linear indent. Vomerine teeth in from three to five longitudinal series; splenial dentition restricted to a space considerably separated throughout its extent from the thin oral border of the bone, comprising one principal series of teeth, flanked within by at least one small series and outside by two or more small series. Scales robust, confined to the anterior part of the trunk in advance of the median fins, and ornamented with reticulating rugæ.

---

[1] K. A. von Zittel, "Handbuch der Palæontologie," vol. iii. (1887), p. 249.

[2] H. Forir, "Contributions à l'Etude du système Crétacé de la Belgique," Ann. Soc. Géol. Belg. vol. xiv. (1887), Mém. p. 25. Also *ibid.* vol. xvi. Mém. p. 445.

The fragments of Pycnodont dentition to be provisionally grouped under this generic name are numerous and widely distributed in the Cretaceous formations of Europe, and comprise, among others, the fossils named *Pycnodus subclavatus*, *P. Muensteri*, and *P. cretaceus* by Agassiz. On the present occasion, however, it is not proposed to refer to more than two new forms; an attempted revision of the whole subject being deferred to the forthcoming Part III. of the British Museum Catalogue of Fossil Fishes. One of these new forms is a common fossil in the Cambridge Greensand; the other is represented by a fine specimen in the Brighton Museum, from the Sussex Chalk, affording much information concerning the structure of the Pycnodont skull. For the opportunity of studying the finest examples of the first-named species the writer is indebted to Prof. McKenny Hughes and Henry Woods, Esq; for the privilege of examining the second to Henry Willett, Esq., and to Edward Crane, Esq., Chairman of the Brighton Museum Committee.

ANOMŒODUS SUPERBUS, sp. nov. Plate XVI. Figs. 5, 5*a*.

Type. Left splenial; Woodwardian Museum, Cambridge.

A large species known only by the splenial dentition. Teeth of the principal series on the splenial bone slightly arcuated, somewhat tapering and turned forwards at the inner extremity, attaining a breadth more than three times as great as their length; inner teeth in two series, those of the one adjoining the principal teeth large and irregular in form, usually with long axis oblique, and those of the innermost row small and rounded; flanking teeth in three series, smooth, diminishing outwards and all smaller than the large series of inner teeth.

This is one of the commonest forms of Pycnodont dentition in the Cambridge Greensand, and the finest known specimen is shown from the oral aspect in Plate XVI. Fig. 5, from the inferior side in Fig. 5*a*.

Form. and Loc.—Cenomanian; Cambridgeshire.

ANOMŒODUS WILLETTI, sp. nov. Plate XVII. Figs. 1, *a–c*.

Type. Imperfect skull, with dentition; Brighton Museum.

A small species, with teeth very irregularly arranged. Teeth of the principal series on the splenial bone obliquely set, very irregular in size and shape, wide mesially, tapering at each extremity, and not much broader than long; inner teeth relatively large in one series, usually broader than long with axis oblique; outer teeth in about three very irregular series, mostly smaller than the teeth of the inner series. Vomerine dentition anteriorly in three series, posteriorly in five, but extremely irregular; the largest teeth much antero-posteriorly elongated and comprised in the outermost series. Nearly all the teeth indented, the smaller ones having the pit especially conspicuous and surrounded with a crenulated margin.

The type specimen in the Willett Collection, Brighton Museum, exhibits the antorbital portion of the skull with the left mandibular ramus, and was obtained from the Lower Chalk of Glynde, Sussex. It is shown in side view, of two-thirds the natural size, in Plate XVII. Figs. 1, 1*a*; while the splenial and vomerine dentitions are represented of the natural size in Figs. 1*b*, 1*c*.

The skull is much elongated, and the snout must have been acutely pointed. The median septum in the rostral region is robust, with a slight horizontal expansion at its upper edge; and the limits of the ethmoidal bone (*e.*) are indicated by the fact that its structural fibres are directed downwards and forwards, while those of the vomer (*v.*) are horizontal. The vomer appears to have been single, and bears teeth, as already described (Fig. 1*c*). Of the cranial roof only one bone is preserved, a long smooth element on the left side (Fig. 1*a*, *fr.*), evidently to be regarded as frontal.

At the hinder extremity of the vomer, a short distance beyond the limit of the dentition, there is seen the pterygo-quadrate-palatine arcade (Fig. 1, *pt.*); and throughout the length preserved, this is shown to form a continuous, inwardly-curved thin plate fused with the base of the skull (perhaps with the edge of the parasphenoid). The posterior part of the fossil also exhibits a thin median plate (Fig. 1, *pas.*) descending from the inferior face of the parasphenoid. The constituents of the pterygo-palatine arcade cannot be distinguished; but its anterior thickened margin, with a re-entering angle, is shown on the right side (Fig. 1), and the robust quadrate articulation, much deeper than broad, with its hollowed facette for the attachment of the mandible, is preserved on the left (Fig. 1*a*, *qu.*). To the postero-external border of the quadrate and its supporting bones on each side, there is also firmly fixed an outer element, with rugose surface, much expanded below and contracted above, which evidently occupies the situation of a pre-operculum (*p. op.*). Its correct shape is shown on the left side (Fig. 1*a*, *p. op.*), and this seems to be the bone already described in *Gyrodus* as "maxilla."[1] The imperfect mandible is also shown, a fragment of the right ramus being displaced to the extremity of the snout (Fig. 1), and the left ramus being nearly complete, though much fractured (Fig. 1*a*, *md.*, Fig. 1*b*.). The structure of the mandible is not clear; but the articular element (Fig. 1*b*, *ar.*) exhibits a very deep undulating facette, and on the splenial (*spl.*) the dentition appears to be restricted to a surface considerably within the external margin of the bone.

Between the two jaws there are also remains of stout bones, perhaps of the hyoid arch, but these are insufficient for determination.

To summarize, the skull of *Anomœodus Willetti* shows that (i) the vomer is single; (ii) the mandibular suspensorium is strongly inclined forwards; (iii) the pterygo-palatine arcade is delicate, toothless, and fused throughout the greater part of its length with the base of the skull; (iv) the parasphenoid has a deep inferior lamellar keel; (v) the articulation of the mandible is very deep and narrow; and (vi) there is a large superficial bone apparently to be identified with the pre-operculum. On comparing the arrangement with the skulls of recent fishes no closer parallel can be found than in some of the Plectognathi, where the specialization seems to be much of the same character. Whether, however, the agreement be a real proof of close affinity, or whether it be merely a case of similar mechanical conditions leading to analogous modifications, cannot be determined until the osteology of all the principal Pycnodont genera has been investigated.

---

[1] A. Wagner, Abhandl. k. bay. Akad. Wiss., math.-phys. Cl., vol. ix. (1862), p. 326. Also K. A. von Zittel, "Handb. Palæont." vol. iii. (1887), p. 239, fig. 251.

Form. and Loc.—Turonian; Sussex.

3. DESCRIPTION OF THE SPLENIAL DENTITION OF TWO NEW SPECIES OF *CŒLODUS.*

There still remains much fragmentary evidence of species of *Cœlodus* hitherto unrecognized, and it seems advisable to propose specific names for the two well-marked new forms of splenial dentition described below. The specimen from the Chalk is as yet unique, and but few examples of the Cambridge Greensand fossil have come under the writer's notice.

CŒLODUS INÆQUIDENS, sp. nov. Plate XVII. Fig. 5.

Type. Left splenial, with dentition; British Museum.

A species of moderate size, known only by the splenial dentition. Teeth of principal series attaining a breadth somewhat more than twice as great as their length, and exceeding in width the two flanking series, of which the inner teeth slightly exceed the outer in size, all being about as broad as long; a row within the principal series represented by few minute round teeth; all the teeth smooth.

This species is noteworthy for the smoothness and relatively small size of the two flanking series of teeth on the splenial bone.

Form. and Loc.—Cenomanian; Cambridgeshire.

CŒLODUS FIMBRIATUS, sp. nov. Plate XVII. Fig. 6.

Type. Imperfect right splenial dentition; British Museum.

A large species, known only by the splenial dentition. Teeth of principal series on the splenial bone smooth or feebly crimped round the margin, somewhat less than three times as broad as long, about equalling in width the two outer series, which are nearly similar in size, irregular in form, slightly broader than long, and have a deep coronal pit with rugose or crimped margin.

The type and only known specimen shown of the natural size in Pl. XVII. Fig. 6, was obtained from the Lower Chalk of Halling, Kent.

Form. and Loc.—Turonian; Kent.

4.—SOME UNDETERMINED SPECIMENS OF THE VOMERINE DENTITION.

Among Cretaceous Pycnodonts there is a general tendency for the dentigerous face of the vomer to become narrowed and convex in transverse section; while three series of teeth are alone well developed, the outer flanking series being usually very small and placed quite on the side of the bone. There is, however, as yet no means of distinguishing the vomer of *Cœlodus* from that of *Anomœodus*; and none of the detached specimens hitherto discovered can be referred with certainty to the species named from the evidence of lower jaws.

In recording some new examples of the vomerine dentition from Cretaceous rocks, it is therefore inadvisable to attempt their specific and generic determination; and we merely give the accompanying figures of four well-marked types (Plate XVII. Figs. 2–4, 7) without names. The original of Fig. 2, in the British Museum, was obtained from the Greensand of the Isle of Wight, and comprises three series of tumid, faintly indented teeth almost in one plane, with a very minute outer series well on each side of the bone. The originals of Figs. 3 and 4, in the Woodwardian Museum, are from the Cambridge Greensand: the first is remarkable for the relatively great width of the median teeth and the convexity of the dentigerous face (best observed in side-view, Fig. 3*a*), while the second is noteworthy for the flatness of the grinding surface formed by the three principal series of teeth.

Most interesting of all, however, is the small vomerine dentition from the Chalk of Charing, Kent, shown of twice the natural size in Fig. 7—a form represented in the British Museum by still another larger specimen from the Chalk of Southeram, Sussex. The worn teeth are coarsely punctate, and all seem to have been obtusely conical, though sometimes with an apical indent. Similar detached teeth have already been found in the Chalk of Bohemia and Saxony, and described under the name of *Pycnodus scrobiculatus*[1]; while portions of the vomerine dentition exactly similar to those now made known from the English Chalk have been described and figured by Geinitz[2] from the Turonian of the valley of the Elbe. Nothing is known of the true generic relationships of the fossils, and they may thus at present remain under the provisional name originally proposed by Reuss.

EXPLANATION OF PLATES.

PLATE XVI.

Fig. 1.—*Athrodon intermedius*, sp. nov.; left splenial dentition. Purbeck Beds; Aylesbury. [British Museum, No. 40314.]

,, 2.—*Athrodon tenuis*, sp. nov.; right splenial, from the oral, inner (2*a*), and inferior (2*b*) aspects. Lower Senonian; Lonzée, near Gembloux, Belgium. [Royal Museum, Brussels.]

,, 3.—*Athrodon crassus*, sp. nov.; right splenial, from the oral, inner (3*a*), and inferior (3*b*), aspects. Cambridge Greensand; Cambridge. [Woodwardian Museum, Cambridge.]

,, 4.—*Athrodon*, sp.; vomerine dentition. *Ibid.* [Woodwardian Museum.]

,, 5.—*Anomœodus superbus*, sp. nov.; left splenial, oral and inferior (5*a*) aspects. *Ibid.* [Woodwardian Museum.]

,, 6.—*Mesodon Damoni*, A. S. Woodward; left splenial, inferior aspect. Portland Stone; Weymouth. [British Museum, No. P. 6165.]

---

[1] A. E. Reuss, "Versteinerungen der böhmischen Kreideformation" (1845), p. 10, pl. iv. figs. 15–25, 64.

[2] H. B. Geinitz, Palæontogr. vol. xx. pt. i. (1875), p. 301, pl. lxv. figs. 31, 32.

PLATE XVII.

Fig. 1.—*Anomœodus Willetti*, sp. nov.; anterior portion of skull, viewed from the right and left (1*a*) sides, two-thirds nat. size. Also the left mandibular ramus, inner aspect (1*b*), and the dentigerous face of the vomer (1*c*). Lower Chalk; Glynde, Sussex. *ar.* articular; *e.* ethmoid; *fr.* frontal; *md.* left mandibular ramus; *p.op.* pre-operculum; *pas.* parasphenoid; *pt.* pterygo-palatine arcade; *qu.* quadrate; *spl.* splenial; *v.* vomer. [Willett Collection, Brighton Museum.]

,, 2.—Pycnodont Vomerine Dentition, oral aspect. Greensand; Isle of Wight. [British Museum, No. P. 3758.]

,, 3, 4.—Pycnodont Vomerine Dentition, oral aspect and side-view (3*a*). Cambridge Greensand; Cambridge. [Woodwardian Museum.]

,, 5.—*Cœlodus inæquidens*, sp. nov.; left splenial. *Ibid.* [British Museum, No. 36157.]

,, 6.—*Cœlodus fimbriatus*, sp. nov.; imperfect right splenial dentition. Lower Chalk; Halling, Kent. [British Museum, No. 43090.]

,, 7.—*Pycnodus scrobiculatus*, Reuss; vomerine dentition, twice nat. size. Chalk; Charing, Kent. [British Museum, No. P. 322.]

Unless otherwise stated the figures are of the natural size.

Erratum.—On page 435 the numbers of the figs. of *Athrodon crassus* and *A. tenuis* are transposed; *for* Fig. 2 *read* Fig. 3, and *vice-versâ.*

III.—On a Bed of Oolitic Iron-ore in the Lias of Raasay.[1]

By Horace B. Woodward, F.G.S.

[Communicated by permission of the Director-General of the Geological Survey.]

The rocks of Raasay have attracted a good deal of attention from geologists, despite the fact that no house of public entertainment exists on the island. That portion of it which lies to the south of Brochel Castle, exhibits a base of Torridon Sandstone, above which there may be traced, more or less completely, in two faulted areas, an ascending series from the New Red rocks to the Great Oolite group. The Jurassic strata are finely exhibited in the eastern cliffs, but westwards they are largely covered by volcanic rocks, and especially by great sheets of Granophyre which descend in that direction to the sea-level. To the south-west there is a mass of Gabbro; in other parts there are sills and countless dykes of Basalt, while the summit of Dun Caan is formed of a bedded mass of that material. Coverings of Peat, of Boulder-Clay and Gravel, serve to add variety to the geology, and to obscure the outcrops of the Jurassic and other rocks.

Our knowledge of the geology is due principally to the labours of Macculloch and Murchison, followed by those of Sir Archibald Geikie, Dr. Bryce, Prof. Tate, and Prof. Judd.

Sir Archibald Geikie, in 1857, constructed a geological map of the island, on the Admiralty Chart, on the scale of about 2⅓ inches to a mile, but this work has not been published, except in a very reduced form on geological maps of Scotland.

In the summer of last year, I commenced the mapping of the Jurassic rocks of Raasay for the Geological Survey, on the scale of

---

[1] Read before Section C, at the meeting of the British Association at Nottingham.

6 inches to a mile. In the end, I have had the satisfaction of finding my work in harmony with that of previous observers; and that the main features depicted on Sir Archibald's map coincided well with the stratigraphical divisions and faults I had traced, while working independently on the far better (though by no means perfect) sheets of the Ordnance Survey.

It will be needless to refer in detail to the observations published by others, as my object is simply to record the fact that during the course of my work I came across a bed of oolitic iron-ore that has not been previously noticed.

This iron-ore occurs in the uppermost part of the Middle Lias, on top of the calcareous sandstones that yield *Ammonites spinatus*, *Gryphæa cymbium*, *Pecten æquivalvis*, *Rhynchonella tetrahedra*, *Terebratula punctata*, and *Waldheimia cornuta*; and beneath the dark shales of the Upper Lias that yield *Ammonites communis*, *A. serpentinus*, *A. exaratus*, etc.

The ironstone itself yields fossils, but not in abundance, and too poorly preserved for specific identification. They include *Ammonites*, *Belemnites*, *Astarte*, *Pecten*, *Rhynchonella*, and pieces of fossilized wood. The iron-ore is a greenish-grey oolitic rock, weathering brown at the surface and along the joints; and it attains a thickness of five feet. Occasionally a thin layer of oolitic ironstone occurs above the main mass, near the base of the Upper Lias shales; and from this horizon I have obtained *Ammonites annulatus* and *A. communis*.[1]

The position of the Raasay ore therefore corresponds approximately with that of the Cleveland ironstone, although in Yorkshire the upper part of the Middle Lias contains a number of ironstone bands. Mr. George Barrow, to whom I showed a specimen of the Raasay ore, remarked that it precisely agreed with Yorkshire examples with which he is so familiar. In composition, as well as in other characters, the Raasay ore compares well with that of Cleveland, for analyses made by Mr. A. B. Dick show that they are practically identical. The Raasay ore yields 29 per cent. of metallic iron in the grey rock (carbonate), and 37 per cent. in the brown rock.

The iron-ore may be traced in several places on and near the footpath that leads from Loch a Mhuilinn, near Raasay Manse, towards Dun Caan, on the borders of the Inverarish Burn and its tributaries. It occurs near Macdonald's Glen, and some distance east of the main cascade, where the waters tumble over a mass of Granophyre that is faulted on the west against the Middle Lias. It may be traced for a mile at various points along this eastern outcrop; but further on towards Hallaig the strata are obscured by peaty coverings and *débris*, due to land-slipping. Again, the iron-ore may be found along the eastern slopes of Beinn na Leac, where the beds are much slipped, so that the true outcrop is almost wholly obscured. Nowhere along the grand cliffs below Dun Caan and onwards to Screapadal could I find any evidence of the iron-ore, nor was there any clear junction between the Middle and Upper Lias that was accessible. These cliffs rise in places, with an almost vertical face, to 800 or 900 feet; and if we include the higher steep slopes and the rough crag of Dun Caan, we have the somewhat dizzy height of 1455 feet. Hence the inaccessibility of the rocks in some places, and the landslips and tumbled blocks in others, render it impossible to follow everywhere the junction of Middle and Upper Lias. On this account it will be easily understood how the presence of the band of iron-ore escaped the notice of previous observers, who naturally devoted their chief attention to the coast-sections and to the strata displayed on the fore-shores. It was only by examining all exposures of the strata in banks and braes, and along the beds of burns, that I found the iron-ore *in situ*, and ascertained its persistence on the same horizon where the strata are exposed.

---

[1] The species of fossils collected by me were named by Messrs. G. Sharman and E. T. Newton.

Dr. Bryce noticed the occurrence of "slightly ferruginous bands" in the Middle Lias, near Portree, in Skye; and he observed also, in the Upper Lias, a band of "nodular blue limestone, showing oolitic structure." These facts I can confirm from a general examination of the cliffs north and south of the entrance to Portree harbour; but I failed to find any evidence of a band of iron-ore equivalent to that of Raasay. The facts now brought forward, however, serve to strengthen the remarks of Dr. Bryce in reference to the Jurassic strata of Skye and Raasay, for he says: "The lithological characters of the beds have a remarkable similarity throughout, and a close resemblance to the structure of the beds on the Yorkshire coast."[1] I may add that I was greatly struck with the general similarity between the lithological characters of the several divisions of the Lias and underlying Red rocks in Raasay, and those familiar to me in the West of England; and among the fossiliferous rocks this similarity in lithology is accompanied by many identical organic remains. The Oolitic Series approximates more closely to the Yorkshire type.

IV.—The Recent Geological History of the Arctic Lands.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

SINCE writing my previous paper on the question of whether, during the so-called Glacial period, the Arctic lands had a milder and not a more severe climate, I have met with some evidence on the subject so important and suggestive that I feel sure it will be welcome to some of your readers, especially as it involves a considerable departure from conventional views. In 1861 Sir Joseph Hooker wrote his famous paper on the distribution of Arctic plants, in which he argued that the flora of Greenland is distinctly of European type; that Greenland is a sub-region, in fact, of the Scandinavian Botanical province. To state his own conclusion in his own words, "the flora of Greenland is almost exclusively Lapponian, having an extremely light admixture of American or Asiatic types." This view had already been maintained by Charles Martins in 1839, although he had not the same materials to work upon. Speaking of the plants of Shetland, the Faroes, Iceland and Greenland, he says: "La migration européenne est évidemment prédominante." Hooker's view was supported by Blytt, who, writing in the Journal of Botany for 1887, says: "Even the Greenland flora consists principally of Scandinavian plants." Sir Joseph Hooker further concluded "that the existing Scandinavian flora is of great antiquity; that previous to the Glacial epoch it was more uniformly distributed over the Polar zone than it is now; that during the advent of the Glacial period the Scandinavian vegetation was driven southwards in every longitude, and even across the tropics into the south temperate zone; and that, on the succeeding warmth of the present epoch, those species that survived both, ascended the mountains of the warmer zones, and also returned northwards, accompanied by aborigines of the countries they had invaded during their southern migration." He further says: "If it be granted that the Polar area was once occupied by the Scandinavian flora, and that the cold of the Glacial epoch did drive this vegetation southwards, it is evident that the Greenland individuals, from being confined to a peninsula, would be exposed to very different conditions to those of the great continents. In Greenland many species would, as it were, be driven into the sea—that is, exterminated; and the survivors would be confined to the southern portion of the peninsula, and not being there brought into competition with other types, there could be no struggle for life among their progeny, and consequently no selection of better adapted varieties. On the return of heat these survivors would simply travel northwards, unaccompanied by the plants of any other country."

---

[1] Quart. Journ. Geol. Soc. vol. xxix. p. 338.

The general conclusion of Hooker and others about the affinities of the Greenland flora, and the widespread induction based upon it, have been recently sharply contested by two Scandinavian botanists. In 1880 Joh. Lange, in his "Conspectus Florae Grönlandicae," came to the conclusion that out of 386 species of Greenland plants 15 are endemic, 40 belong to the Western or American, and 44 to the Eastern or European district; that is to say, are otherwise only found in those districts; or, interpreting the facts most favourably to the Eastern side, there would be 36 Western as against 42 Eastern—a majority of six only in favour of the latter.

Some years later Warming subjected the botany of Greenland to a minute analysis and came virtually to the same opinion as Lange. He divides Greenland into two botanical provinces—a birch region (R. sub-Alpina) and an Alpine region (R. Alpina). The former is limited to the extreme south of Greenland, and is bounded by a line from Cape Farewell, 60° North lat. on the East coast, to about 62° on the west, and contains about 60 species of plants not otherwise found in Greenland. The other region includes all the rest of the country. His conclusion is, that while the former small district contains a considerable number of specially European types, the latter, viz. Greenland proper, contains hardly any; but does contain a number of American ones. The great bulk of the plants, however, of Greenland belong neither to Europe especially nor to America, but are distinctly Circumpolar. Its 15 endemic plants consist of six species of *Carex*, three of *Potentilla*, *Epilobium ambiguum*, *Arabis Breutelii*, *Campanula grönlandica*, *Calamagrostis hyperborea*, *Glyceria Langeana*, *Poa filipes*.

Of the specially European plants, most of which are only found in the extreme south of the island, Warming considers that a large proportion have found their way there since Glacial times either by ocean currents, by being carried by birds, and in other ways. It would seem most certain, in view of his very careful analysis of the problem, that Hooker's original view can no longer be maintained and that Greenland cannot be treated as a section of the Scandinavian botanical province. Nor can we fairly treat it as a section of the North American botanical province either. On the contrary, it seems plain that it forms an integral part of what ought to be discriminated as a Pan-Arctic or Circumpolar botanical region.

This raises some very important questions and notably those connected with the Ice-age. The notion that the flora of Greenland was virtually exterminated by the Ice-age and has found its way thither again since that period must go to the wall, as Warming emphatically urges, and we cannot avoid his conclusion, that the present flora of Greenland outlived the so-called Glacial age there. Warming says further that Greenland during the Ice-age clearly had ice-free land. The many Danish geological and geographical expeditions which during the last ten years have visited the country have mapped it and described its geology and botany, and have made it plain that in S. Greenland, above the height of two to three thousand metres there is no mountain top showing any signs of former ice action. This would include several isolated mountains along the west coast, as far north as 70° of N. Latitude and a large part of the uplands of S. Greenland. Warming emphatically says there is no trace here of a general ice-covering, but only of local glaciers; it is here, he urges, that the plants we are discussing continued to live. Another similar vantage for them was in N.E. Greenland in the neighbourhood of Franz Josephs Fiord, where also there is evidence, that the land was not mantled with ice. Similar conditions also probably prevailed in Grinnell land, where Greeley, and about Discovery Bay in 82° 44′ North lat., where Nares found a comparatively rich vegetation with several very local species.

Warming further urges that the survival of the present fauna of Greenland from pre-Glacial times is also attested by the rarer plants. Putting aside South Greenland, where a considerable number of the plants may have been imported in post-Glacial times, the second German Polar Expedition found a number of plants in north-east Greenland such as *Polemonium humile*, *Arabis petræa*, *Saxifraga Hirculus* and *hieraciifolia*, *Draba altaica*, *Ranunculus glacialis*, etc., which are either not found elsewhere or in very few places. "It seems to me probable," says Warming, "that most of these, probably all, are to be numbered among the Autochthones." In north-west Greenland we find such rarities as *Pleuropogon Sabinei* and *Hesperis Pallasii*, which also probably outlived the ice period. *Androsace* *septentrionalis,* which the Nares' Expedition found in Grinnell land, is there removed by a long distance from where it otherwise occurs. On the west coast are other rare plants, as *Ranunculus glacialis* south of Upernivik; *Eutrema Edwardsii* in latitude 70° 47′; *Taraxacum phymatocarpum* in 70°–74′ North latitude; *Utricularia minor* from 68°21′–69°, elsewhere it occurs in the Urals and the Altai. *Scirpus parvulus,* found in two places between 68° and 69° North lat., also European; *Cerastium arvense* found once in 67° 5′ North lat.; *Carex helvola,* also found in 67°, and also European; *Linnæa borealis,* found in 1883, near Ivigtut in 61° 10′ and in 1884 about 67°. *Arctostaphylos alpina,* sparingly between 70° and 65°; *A. uva ursi* only in one place, about 67° North lat. near Holstensborg; *Sisymbrium humile,* found in 1884 in the upper part of "Sondre Stromfjorde," in 66° 30′ North lat. Then among plants only found otherwise in America and West Siberia: *Gentiana tenella,* found in 1889; *Vahlodea atropurpurea, Andromeda polifolia, Rubus chamæmorus,* only found in Godhavn in 64° 10′ North lat. and several others. "The distribution of these plants," says Warming, "seems to me to point to their being relics of the old flora which have survived in favourable localities." He further argues that while some plants have managed to survive, others have succumbed, and notably such widespread genera as *Chrysosplenium* and *Caltha,* and also the various genera of *Oxytropis, Astragalus, Phaca,* etc., which are so widely spread in Alpine districts, and also in the Arctic regions, but are not found in Greenland. One of the most notable absentees from Greenland is the *Salix polaris,* which occurs in Spitzbergen, Scandinavia, North Russia, Siberia, and North America as far as Davis Straits.

These conclusions in regard to Greenland may be paralleled by those of Nathorst, in regard to Spitzbergen. He also concludes that the flora of that island, instead of being an importation since Glacial times, is really the wreck and ruin of what was once a much richer flora, and which has been able to survive the drastic conditions which now prevail there.

Warming argues that the specially European plants found in South Greenland are probably colonists from Iceland. In regard to Iceland itself it seems impossible to believe that its comparatively rich flora is the result of sporadic colonization. Long ago Pennant wrote, in his ingenuous way, that "there are found in Iceland 309 perfect and 233 cryptogamous plants, while on the Island of Ascension, which is totally and aboriginally volcanic, a flora of not more than seven plants is to be seen." This means that either Iceland has been connected with Europe by a land-bridge since Glacial times, or that its flora survived the Glacial age, which is much more probable.

Quite recently an examination of the flora which has appeared on the uncovered moraine of the great glacier in Alaska seems to point to the same lesson, while the instances of trees with their roots attached, which were found by Maclure and other Arctic navigators in the Arctic Archipelago of North America, seem to point also in the same direction. They all apparently converge upon one conclusion, namely, that if there has ever been a so-called Glacial period in the Arctic regions it is now. That the present period is *the* one period in their history when the reign of ice and snow has been dominant, that, so far as we can make out, their climate has been becoming more and more severe in historic times, and that in the Pleistocene age, so far as we have evidence, the climate of the Polar area was more and not less temperate than now. All this is completely at one with the more recent speculations of the zoologist, who sees in the Polar area the centre and focus of a geographical region, in which the animal forms are alike in all meridians, namely, the so-called circumpolar area, and who further argues that the two provinces which are known as Palæarctic and Nearctic, in so far as they are differentiated from each other, have become so very recently, and that in all probability they constituted in Pleistocene times one continuous and homogeneous district with the Arctic lands, a province marked by a similar fauna and flora. This again is confirmed by such facts as the occurrence of the great sea-cows which Steller discovered in Behring's Island, in a latitude far away from all their relatives and congeners. They are essentially animals which thrive under temperate or sub-tropical conditions, and this colony, so lately occurring in the North Pacific, seems to point very clearly to the climate of that region having been recently milder. The same conclusion as I have previously argued seems to follow, if we are to find any rational explanation of the problem of the northern migratory birds—birds which pass their summer in the Arctic and sub-Arctic lands and are scattered far and wide during the winter. Their types are so essentially northern that we can hardly doubt that at no remote time they were living all the year round in their present breeding quarters in Greenland and Spitzbergen, no less than in Northern Siberia. The cold which has deprived these birds of any suitable food and resting-place in the winter is the cold now prevailing, and not a much more severe cold dating from the Pleistocene age; and in explaining the difficulties and paradoxes of the distribution of animal life in the northern hemisphere, we must, as in the case of the vegetable life, invoke not a portentous period of ice in the last age of the world, but an increasing cold from the time of the Mammoth onwards and culminating in our own day. If this be so we may well advance another step and enquire what was the cause which has chiefly operated to bring about this result. Since it is one which is most potent at this moment, and which has been growing in intensity in historic times, it ought to be explained without appealing to transcendental causes, which are so easy to invoke, however hard they may be to justify, when we are dealing with a long-departed past.

In regard to Siberia, I have in previous papers endeavoured to offer an explanation of the problem as partially explained by the upheaval of the Tibetan plateau, and of the Himalayas and Altai, as Humboldt long ago argued, and partly by the stoppage of Behring Straits, which prevented the Polar current from reducing the temperature of Kamschatka and the Sea of Okhotsk.

In regard to Greenland, Spitzbergen, Iceland, and the Arctic Archipelago of America, etc., it seems impossible to disconnect the increasing severity of their climate with the contemporary and correlative gradual elevation of these northern lands above the sea-level. The fact is familiar enough in regard to some of them, and I myself in almost the first scientific paper I ever wrote, and published in the Journal of the Royal Geographical Society (since reprinted in the Arctic Manual), adduced a great deal of evidence on the subject to show that the area of current elevation in the Northern Hemisphere is continuous. Wherever the coasts of the northern lands have been examined (except only the southern extremity of Greenland, where the reverse seems to prevail) there is evidence of stranded Whales, drift timber, and of raised beaches, showing the very recent and continuing rise of the land.

This rise was necessarily concurrent with a corresponding alteration in climate, due to the accumulation of snow and ice above the snow line, the growth of glaciers and the dispersal of icebergs, and apart from the direct evidence already adduced it would have been possible and necessary to postulate such a change of climate, as a deduction from the fact of this recent elevation of the land alone. Here then we have a potent and efficient cause which is known to have been in active operation, and to which we can hardly fail to attribute the climatic changes above described. To shortly state the general conclusions which I would press :—

I. During the Pleistocene period the Arctic lands, instead of being overwhelmed by a glacial climate, were under comparatively mild conditions, and were the home of a widely spread and homogeneous fauna and flora constituting, perhaps, the best defined life-province in the world.

II. Since Pleistocene times the climate of these Arctic lands has been growing more and more severe, resulting in the extinction of a portion of their vegetable and animal inhabitants.

III. While one portion of this Pan-Arctic fauna and flora still remains largely homogeneous, another portion has become differentiated by evolution in Northern America and Northern Europasia, into the Nearctic and Palæarctic regions respectively.

IV. The true and the only Glacial climate which we know to have prevailed in the Arctic lands was not during the so-called Glacial age of geologists, that is during the Pleistocene period, but is that which is now current, and which is the product largely, if not entirely, of changes of level in the earth's crust which have occurred since Pleistocene times.

These conclusions, if sustained, ought to throw some light on the problem of finding a rational explanation of the Glacial phenomena of the temperate zones, and notably of North-eastern America and North-western Europe. I may, perhaps, be allowed to discuss this on another occasion.

I have to thank Mr. Howell for his very interesting letter, in which he supports my contention that there are no traces of former wide-spread ice-sheets in Iceland and only of local glaciers.

V.—THE GEOLOGICAL DEVELOPMENT, DESCENT AND DISTRIBUTION OF THE MAMMALIA.

By Prof. KARL A. VON ZITTEL, Ph.D., For. Memb. Geol. Soc. Lond.;
Professor of Palæontology in the University of Munich.

(*Concluded from page* 468.)

PLIOCENE.

THE Pliocene mammalian land fauna lived at a period when Europe had already obtained the main features of its present configuration. Italy, to be sure, at the beginning of this period was still partly overflowed by the sea, and in Belgium, Holland, and the South of England, the North Sea extended further over the land than to-day and left behind the deposits known as the Crag. Over the extended mainland of Central Europe, the conditions for the preservation of mammals were, on account of the absence of more extended fresh-water lakes, extremely unfavourable. Only the volcanic tuffs in Auvergne, the fissures filled with Bohnerz of the Upper Rhone valley, and the scattered fresh-water deposits of the Rhone valley, Roussillon and the neighbourhood of Montpellier, contain remains of the Pliocene land fauna, which are handed down in greater perfection in the swampy, and in part coal-bearing, sediments of the Arno valley and in the partly marine formations of Piedmont and the Romagna.

These consist of the following genera[1]:—

PERISSODACTYLA.
Tapirus.
Rhinoceros.
(*Atelodus.*)
(*Cœlodonta.*)
***Equus.**
†*Hipparion* (rare).

ARTIODACTYLA.
Sus.
***Hippopotamus.**
***Cervus** (*Elaphus*).
*(**Polycladus.**)
*(**Axis.**)
*(**Capreolus.**)
***Alces.**
**Dama.*
***Cervulus.**
†**Palæoryx.**
Gazella.
†*Tragelaphus.*
Antilope.
***Bos.**
***Leptobos.**
Bubalus.

PROBOSCIDIA.
†**Mastodon.**
***Elephas.**

RODENTIA.
Arctomys.
†**Steneofiber.**
***Castor.**
* *Trogontherium.*
Cricetus.
*† *Trilophiomys.*
***Arvicola.**
***Mus.**
Hystrix.
*†*Ruscinomys.*
*†*Pellegrinia.*
**Lepus.*
**Myolagus.*
**Lagomys.*

INSECTIVORA.
Sorex.

CARNIVORA.
(Fissipedia.)
**Canis.*
†*Hyænarctos.*
***Ursus.**
*†*Ælurus.*
Putorius.
Lutra.
Viverra.
Hyæna.
Machairodus.
Felis.

PRIMATES.
***Semnopithecus.**
*†*Dolichopithecus.*
†*Macacus.*

The above table shows that the ancient genera *Mastodon* and *Tapirus* become extinct in Europe, whilst in North America and in the East Indies they continue into the Pleistocene. Amongst the new genera which spring up, some (*Equus, Hippopotamus, Bos, Lep-*

---

[1] The genera marked with * appear for the first time in the Pliocene; those marked with † become extinct.

tobos, Bubalus, Elephas, Ursus, Canis) appear to have wandered from out of Asia, and these, together with the numerous forms of Deer, which were already split up into several sub-genera, chiefly contribute the peculiar character of the Pliocene fauna. In spite of their modern habitus, the Pliocene forms are linked unconditionally to the older forerunners of the Miocene period, and of not a single order can it be asserted that the thread of continuity between Miocene and Pliocene has been completely broken. But in a far higher measure than previously the dawn of the present time is reflected in the forms of the Pliocene Mammalia. With the exception of some mostly imperfectly known representatives of the microfauna, the only Pliocene genera which are wanting in the present period are *Hipparion, Mastodon, Hyænarctos, Machairodus, Leptobos,* and *Dolichopithecus.* A much greater number of genera have indeed forsaken their European dwelling-places and withdrawn into warmer regions. Tropical Africa and India are the places of refuge in which a considerable portion of the Pliocene genera were preserved, and in the course of time more or less transformed. No single Pliocene species has maintained itself unchanged to the present. That the Pliocene fauna of India agreed in character with that of Europe is evident from the fact that the Upper Sivalik beds and the newer deposits in the valleys of the Kistna, Narbada, Jumna, Godavari, and Pemganga, contain not only the same genera, but partly even identical, or nearly identical, species.

The Cetacea, Pinnipedia and Sirenia, which are present in great abundance in the Crag deposits of Antwerp, Holland, and Suffolk, and in the Marine sub-Apennine beds of Italy, occupy a similar intermediate position between the Miocene and the Present to that of the land fauna. They contain the following genera :—

Cetacea.
Squalodon.
Eurhinodelphis.
Priscodelphinus.
Delphinus.
Steno.
Tursiops.
Orca.
Globicephalus.
Physeter.
Physeterula.
Homocetus.
Physodon.
Scaldicetus.
Hoplocetus.
? *Priscophyseter.*
? *Physotherium.*
Hyperöodon.
Choneziphius.
Placoziphius.
Dioplodon.
Berardiopsis.
Plesiocetus.
Heterocetus.
Amphicetus.
Herpetocetus.
Idiocetus.
Mesocetus.
Isocetus.
Balænoptera.
Megaptera.
Balæna.
Palæocetus.

Sirenia.
Felsinotherium.
Halitherium.

Pinnipedia.
Pristiphoca.
Palæophoca.
Mesotaria.
Callophoca.
Platyphoca.
Phocanella.
Gryphoca.
Trichechus.
Alachtherium.

In North America the so-called Loup Fork or *Pliohippus* beds of Niobrara, Nebraska, Wyoming, Colorado, Kansas, New Mexico, Texas, and Mexico, are usually reckoned to the Pliocene, and they are especially characterized by the abundance of *Mastodon, Aphelops, Hipparion, Pliohippus, Protohippus, Merychyus, Merycochœrus,* Camels, Rodents, and Carnivora. The absence of *Elephas,* horned Ruminants, _Tragulidæ_, Deer, Bears, and Apes, gives to this fauna rather a Miocene than a Pliocene stamp, and justifies the opinion of Cope, who places these beds in the Upper Miocene. They contain the following genera:—

PERISSODACTYLA.
__Hipparion__ (E.)
Merychippus.
__Protohippus.__
__Pliohippus.__
__Equus__ (E.)
Tapiravus.
__Aphelops.__

ARTIODACTYLA.
__Merychyus.__
__Merycochœrus.__
__Protolabis.__
__Procamelus.__

Camelus.
Pliauchenia.
__Cosoryx.__

PROBOSCIDIA.
__Mastodon__ (E.)

RODENTIA.
__Eucastor.__
Mylagaulus.
__Hesperomys.__
__Palæolagus.__
Punolax.

? _Geomys._
? _Thomomys._

CARNIVORA.
(Fissipedia.)
Ælurodon.
Canis (E.)
Leptarctos.
Stenogale.
Mustela (E.)
Brachypsalis.
Lutra (E.)
Pseudælurus.

The Loup Fork beds share with Europe the genera _Equus_, _Hipparion_, _Mastodon_, _Canis_, _Mustela_, and _Lutra_, and with South Asia, _Camelus_. On the whole, this fauna is somewhat further removed from that of the Old World; the specialization of peculiar North American forms, already indicated in the Lower and Middle Miocene, has made visible progress. The bond between the two provinces of the Northern hemisphere has become looser.

In South America the Araucanian Formation of Ameghino may correspond with the Older European Pliocene. At Monte Hermoso, near Bahia Blanca, it has yielded about sixty species of Mammalia, which are divided amongst the following genera:—

MARSUPIALIA.
__Didelphis.__

EDENTATA.
Gravigrada.
__Lestodon.__
*__Megatherium.__
*__Scelidotherium.__
Pseudolestodon.
Diodomus.

GLYPTODONTIA.
*_Glyptodon._
__Hoplophorus.__
*__Plohophorus.__
*_Panochthus._
Neuryurus.
Plaxhaplus.

DASYPODA.
__Chlamydotherium.__
Dasypus.
*_Dasypotherium._
Proeuphractus.
Eutatus.

PERISSODACTYLA.
*_Tapirus_ (N.)
(_Antaodon._)
*_Hippidium_ (N.)
__Macrauchenia.__
*__Epitherium.__

ARTIODACTYLA.
*__Auchenia__ (N.)
*_Eoauchenia_ (N.)
*_Paraceros_ (N.)

PROBOSCIDIA.
*__Mastodon__ (N.)

TOXODONTIA.
Toxodon.
*_Trachythœrus._
*_Trigodon._
Xotodon.

TYPOTHERIA.
Protypotherium.

*_Typotherium._
*_Pachyrucos._

RODENTIA.
*_Myopotamus._
*_Tribodon._
*__Eumysops.__
*__Dicælophorus.__
*_Phthoramys._
*_Platæmys._
*__Pithanotomys.__
__Lagostomus.__
Megamys.
*__Orthomyctera.__
*_Microcavia._
*__Palæocavia.__
*_Diocartherium._
*_Phugatherium._
*_Hydrochœrus._
Caviodon.

CARNIVORA.
*_Canis_ (N.)

The Autochthonous Marsupials, Edentates, Perissodactyla, Toxodonts, Typotheria, and Rodents contain genera, in part handed over from older strata, in part new (those marked with *), but these represent, almost without exception, only advanced stages of differentiation of older types. But, in this fauna of the Southern world, one sees now, for the first time, a number of entirely foreign intruders intermingled, which betray a different descent. The genera *Tapirus, Hippidium, Auchenia, Eoauchenia, Paraceros, Mastodon*, and *Canis* have certainly not sprung from the soil of South America, but have migrated from the North, where they already existed, either as identically the same genera or as nearly related representative forms, in the Loup Fork beds. This invasion of strangers from the North shows that the two halves of the Western continent first grew together in the Pliocene period, and that probably at that time a land-bridge, broader even than the present Isthmus of Panama, joined together North and South America and the West Indies.

But not only did the North American types make use of the newly opened way to widen the area of their distribution, but also the forms indigenous to the South began to migrate to the North, and thus brought about one of the most remarkable instances of the overlapping of different faunas which geology has to record. In North America the so-called *Equus*-beds in the West and South-West of the United States (Oregon, California, Idaho, Arizona, New Mexico, Wyoming, Kansas, and Texas), in Mexico and Central America, and the contemporaneous *Megalonyx*-beds in the East (Kentucky, Pennsylvania, Ohio, Carolina, Virginia, Florida), and in the West Indies (Cuba), represent either the last phase of the Tertiary period, or the beginning of the Pleistocene Diluvial period. A peculiar composite fauna of both Northern and Southern descent peopled at that time North America, and left its remains in the deposits just mentioned.

To the Northern types belong the genera *Equus, Hipparion, Tapirus*; *Dicotyles, Platygonus*; *Auchenia, Eschatius, Holomeniscus, Cariacus, Cervus, Alces, Bos*; *Mastodon, Elephas*; *Castor, Erethizon, Castoroides, Sciurus, Arctomys, Jaculus, Arvicola, Thomomys, Geomys, Neotoma, Lagomys, Lepus, Scalops*; *Procyon, Arctodus, Putorius, Mustela, Lutra, Mephitis, Canis, Urocyon, Pachycyon, Chrysocyon, Arctotherium, Felis, Machairodus*; whilst to the South American types belong *Megalonyx, Mylodon, Glyptodon, Chlamydotherium, Hydrochœrus, Amblyrhiza* and *Toxodon.*

PAMPAS FORMATION.

The deposition of the *Equus*- and *Megalonyx*-beds in North America may coincide with the formation of the loamy deposits, resembling the widely-distributed Loess, of the so-called "Pampas Formation" in Argentina and Uruguay. Also the volcanic tuffs of Bolivia, Peru and Chili contain mammalian remains which partly repeat those in the *Equus*-beds of Central America, and partly those in the Pampas mud. In its wealth of forms the fauna of the Pampas formation exceeds that now existing in South America. It contains, according to Ameghino, 235 species and 93 genera. Even if a part of the species indicated in his lists will not stand a more critical review, there will yet remain so large a residue of good genera and species that, on the whole, only the fauna of the Phosphorites and the Bohnerze in Europe, that of the Santa-Cruz formation in Patagonia, and the fauna of the Sivalik Hills can come into comparison with it. Among the specifically South American orders, the Edentates reach, in the numerous kinds of the Gravigrada, Glyptodontia, and Dasypoda, notable dimensions, and in the same way the Toxodonts, Typotheria and the Macrauchenidæ surpass most of their predecessors in size. But this exuberant growth and the extreme specialization of individual organs, which as a rule is associated with it, appear to have been fatal to its possessors, for none of the giant Edentates, Toxodonts, Typotheria, and Macrauchenidæ survived the end of the Pampas formation, and with them, the larger migrants from the North, such as *Mastodon*, *Machairodus*, *Equus*, *Hippidium*, *Mesolama*, *Palæolama*, etc., also became extinct. The invasion from the North, which had already begun during the Araucanian period, introduced a considerable number of new Elements into the South American fauna, among which may be named in the first rank, the Horse, various genera of Carnivora (*Machairodus*, *Felis*, *Mephitis*, *Lutra*, *Nasua*, *Arctotherium*), a very doubtful representative of the Rhinocerotidæ (? *Plicatodon*), a considerable number of small Rodents of the Myomorpha group, and finally —Man himself. The fauna of the Pampas formation contains, according to Ameghino, the following genera[1]:—

MARSUPIALIA.
Didelphys.
†*Dimerodon.*

EDENTATA.
Vermilinguia.
Myrmecophaga.
Gravigrada.
†**Megatherium.**
†*Essonodontotherium.*
†*Neoracanthus.*
†*Ocnopus.*
†*Nothrotherium.*
†*Nothropus.*
†**Mylodon.**
†*Pseudolestodon.*
†**Lestodon.**
†*Laniodon.*
†**Scelidotherium.**
†*Platyonyx.*
†**Glossotherium.**
Glyptodontia.
†**Glyptodon.**
†*Thoracophorus.*
†**Hoplophorus.**
†*Lomaphorus.*
†**Panochthus.**
†*Eleutherocercus.*
†*Neuryurus.*
†**Dædicurus.**
†*Plaxhaplus.*
† ? *Heterodon.*
† ? *Euryodon.*
†*Plohophorus.*
Dasypoda.
Chlamydophorus.
†*Dasypotherium.*
†**Chlamydotherium.**
Tatusia.
Eutatus.
Tolypeutes.
Xenurus.
Cheloniscus.

PERISSODACTYLA.
†**Equus** (N.)
†**Hippidium** (N.)
†**Macrauchenia.**
†*Diastomicodon.*
Tapirus (N.)
† ? *Plicatodon* (N.)

ARTIODACTYLA.
Dicotyles (N.)
Auchenia (N.)
†*Mesolama* (N.)
†*Stilauchenia* (N.)
†*Palæolama* (N.)
†*Hemiauchenia* (N.)
†*Protauchenia* (N.)
†*Eulamops* (N.)
Cervus (N.)
(*Furcifer*) (N.)
(*Cariacus*) (N.)
(*Blastoceras*) (N.)
(*Epieuryceras*) (N.)
Antifer (N.)
Coassus (N.)

PROBOSCIDIA.
†*Mastodon* (N.)

TOXODONTIA.
†**Toxodon.**
†*Dilobodon.*
† ? *Eutrigonodon.*

TYPOTHERIA.
†**Typotherium.**
†**Pachyrucos.**

RODENTIA.
Hesperomys (N.)
Habrothrix (N.)
Oxymicterus (N.)
Scapteromys (N.)
Rhipidomys (N.)
Nectomys (N.)
Calomys (N.)
Reithrodon (N.)

---

[1] The genera marked with † are extinct, those to which (N.) is affixed are of North American origin.

Bothriomys (N.)
Tretomys (N.)
Ptyssophorus (N.)
Holochilus (N.)
Myopotamus.
Ctenomys.
†*Dicælophorus.*
†*Platæomys.*
†*Pithanotomys.*
Schizodon.
Loncheres.
Nelomys.
Mesomys.
Carterodon.
Dolichotis.
Cavia.
Microcavia.
Cerodon.
Hydrochœrus.
Lagostomus.
Lepus (N.)

CARNIVORA.
(Fissipedia.)
Canis (N.)
†*Macrocyon* (N.)
Arctotherium (N.)
Nasua (N.)
†*Amphinasua* (N.)
Lutra.
Mephitis (N.)
Lyncodon (N.)
Felis (N.)
†**Machairodus** (N.)

PRIMATES.
Homo (N.)

If we compare the fauna of the Pampas formation with that now existing in South America, the large proportion of extinct species at once strikes the eye. In this respect it is further removed from that now living in South America than the Pliocene fauna of Europe from its present descendants. On the other hand one finds, however, amongst the fossil animals of the Pampas a large number of still living species, which are altogether missing in the Pliocene of Europe. If we consider, with Ameghino, the Pampas formation as the equivalent of the European Pliocene, we observe that its fauna possesses on the one side a more ancient, and on the other a more modern, character than that in Europe; if, with Burmeister, Steinmann and others, we place it in the Pleistocene, it is distinguished in a remarkable manner from the Diluvial faunas of other parts of the world by the great number of extinct genera and species which are present in it.

It would appear as if the Southern hemisphere required to be measured by a different standard than other places, for Australia also possesses in Bone-caves and in evidently late surface-deposits, generally attributed to the Pleistocene, an extinct fauna, which holds just the same relative position to that now living in that country as the Pampas fauna to that of modern South America. With the exception of a species of Dog (*Canis dingo*) the Pleistocene mammals of Australia belong to the Monotremata and Marsupials, and they are divided amongst the following genera:—

†*Proechidna.*
Perameles.
Dasyurus.
Sarcophilus.
Thylacinus.
Bettongia.
Æpyprymnus.
†*Thylacoleo.*
Pseudochirus.
†*Koalemus.*
†*Archizonurus.*
†*Thylacopardus.*
Macropus.
†*Sthenurus.*
†*Procoptodon.*
†*Palorchestes.*
†*Triclis.*
†*Synaptodus.*
†*Diprotodon.*
†*Nototherium.*
Phascolomys.
†*Phascolonus.*

Here also the fossil extinct genera and species are distinguished by their remarkable size, and just as the Gravigradidæ and the Glyptodontidæ of the Pampas-beds stand out as giants in comparison with the existing Sloths and Armadillos, so also the powerful *Diprotodon, Nototherium, Phascolonus, Sthenurus, Procoptodon, Thylacoleo* and others present a similar contrast to their still existing Australian relatives.

If there prevails in North and South America and in Australia some uncertainty as to the boundary of the Pliocene and Pleistocene, the case is hardly different in Europe; for here also there is thrust in between the typical Pliocene fauna of the Arno-valley, of Auvergne, and of the neighbourhood of Montpellier, a peculiar pre-Glacial composite fauna, of which the most perfect remains lie buried in the so-called Forest-beds of Cromer, in Norfolk, in the sand and gravel deposits of Saint Prest (Eure-et-Loire), Chagny (Saône-et-Loire), Durfort (Gard), in the clays of Leffe (Lombardy), at the Janiculus near Rome, and in other places in Italy.

As characteristic species of this horizon may be considered the following:—

Equus ? Stenonis.
,, *caballus.*
Rhinoceros etruscus.
,, *Mercki.*
(*Rhinoceros leptorhinus.*)
Hippopotamus major.
Sus scrofa.
Cervus Sedgwicki.
,, *verticornis.*
,, *polignacus.*
,, *eurycerus.*

Cervus elaphus.
,, *capreolus.*
Antilope, sp.
Gazella anglica.
Bison, sp.
Bos primigenius.
Elephas meridionalis.
,, *antiquus.*
,, *? primigenius.*
Castor fiber.
Trogontherium Cuvieri.

Sorex vulgaris.
,, *moschatus.*
Talpa Europæa.
Canis lupus.
,, *vulpes.*
Ursus arvernensis.
,, *spelæus.*
Hyæna, sp.
Machairodus latidens.

Of genuine Pliocene species this fauna contains only *Elephas meridionalis*, *Rhinoceros etruscus*, and *Ursus arvernensis*; only *Cervus Sedgwicki* and *C. verticornis* belong to it exclusively; all the remaining species also occur in the genuine Older Diluvium (Pleistocene).

Pleistocene or Diluvium.

The genuine Pleistocene fauna of the European Diluvium contains about 110 species, whilst the mammalian fauna now living in Europe, including the introduced and domesticated forms, consists of about 150 species.[1]

Perissodactyla.
Equus caballus.
,, *hemionus.*
,, *asinus.*
†*Rhinoceros* (*Cœlodonta*) *antiquitatis.*
†(=*R. tichorhinus.*)
†*Rhinoceros Mercki.*
†*Elasmotherium Sibiricum.*

Artiodactyla.
Sus scrofa ferus.
†*Hippopotamus major.*
† ,, **Pentlandi.**
Cervus elaphus.
,, *Canadensis.*
† ,, *eurycerus.*
† ,, *Belgrandi.*
,, *capreolus.*
,, *dama.*
Alces palmatus.
Rangifer tarandus.
Capra ibex.
,, **pyrenaica.**
,, *hircus.*
Antilope rupicapra.
,, *Saiga.*
† ,, **? Maileti.**
Ovis aries.
† ,, **tragelaphus.**
Ovibos moschatus
†*Bos primigenius.*
,, *taurus.*
†*Bison priscus.*

Proboscidia.
†*Elephas antiquus.*
† ,, **Melitensis.**
† ,, **mnaidriensis.**
† ,, **Falconeri.**
† ,, *primigenius.*

Rodentia.
Arctomys marmotta.
,, *Bobac.*
Spermophilus guttatus.
,, *rufescens.*
,, *fulvus.*
,, *citillus.*
Sciurus vulgaris.
Myoxus glis.
,, *nitela.*
Muscardinus avellanarius.
Alactaga jaculus.
†*Trogontherium Cuvieri.*
Castor fiber.
Hystrix cristata.
Sminthus vagus.
Mus sylvaticus.
,, *? musculus.*
Cricetus vulgaris.
Arvicola amphibius.
,, *glareolus.*

---

[1] In the following table only the species from the Mediterranean region are printed in thick type; those with † are extinct.

Arvicola nivalis.
,, *ratticeps.*
,, *gregalis.*
,, *arvalis.*
,, *agrestis.*
Myodes lemmus.
,, *torquatus.*
Lepus timidus.
,, *variabilis.*
,, *cuniculus.*
Lagomys pusillus.
Myolagus Sardus.

INSECTIVORA.
Talpa Europæa.
Myogale moschata.
,, *pyrenaica*
Sorex vulgaris.
,, *pygmæus.*
Crocidura araneus.
Crossopus fodiens.
Erinaceus Europæus.

CHIROPTERA
Vespertilio murinus.
,, *mystacinus.*
Vesperugo noctula.
,, *pipistrellus.*
,, *serotinus.*
,, *borealis.*
Plecotus auritus.
Rhinolophus ferrum-equinum.

CARNIVORA.
Canis lupus.
(=*C. spelæus.*)
Canis lupus Suessii.
Cuon Europæus.
† ,, *Edwardsianus.*
†**Lycorus Nemesianus.**
Canis vulpes.
,, *lagopus.*
† ,, *Mikii.*
†*Ursus spelæus.*
† ,, *priscus.*
,, *arctos.*

Meles taxus.
Gulo luscus.
Mustela martes.
,, *foina.*
Putorius fœtidus.
,, *vulgaris.*
,, *ermineus.*
Lutra vulgaris.
Hyæna spelæa.
(=*H. crocuta* var.)
Hyæna **striata.**
†*Machairodus latidens.*
†*Felis spelæa.*
,, ? *tigris.*
,, *pardus.*
,, **caffra.**
,, *lynx.*
,, *catus.*

PRIMATES.
†*Macacus Suevicus.*
,, **Inuus.**
Homo sapiens.

With the exception of *Elephas primigenius, Rhinoceros antiquitatis, R. Mercki* and *Cervus eurycerus*, the extinct species belong to the Older pre-Glacial or inter-Glacial Diluvium. *Hippopotamus major* is only a larger variety of the African *Hippopotamus*, and similarly *Felis spelæa* and *Hyæna spelæa* stand in the same relation to the Lion and to the African spotted Hyæna. To the pre-Glacial, or, perhaps better, to the inter-Glacial deposits, are reckoned the older stratified gravels, sands and clays of the Seine- and Somme-valleys in Northern France, of the Thames- and Ouse-valleys in England; of the Rhine and Neckar districts (Daxlanden, Mannheim, Worms, Mosbach near Wiesbaden, Mauer near Sinsheim, Hangenbieten in Alsace); the calc-tuffs and sands of Cannstadt and Taubach near Weimar; the inter-Glacial brown coals, gravels and sands of Utznach and Dürnten; the older stratified gravel and sand deposits in the Rhone valley, in Switzerland, in the Swabish-Bavarian high plateau; in the Vienna basin, in Hungary, Roumania, South and Central Russia; in the North German plain (Rixdorf), Italy, and Spain.

As characteristic elements of the Older Diluvial fauna may be placed in the first line *Elephas antiquus, E. primigenius, Rhinoceros Mercki, Equus caballus, Trogontherium Cuvieri, Castor fiber, Sus scrofa, Cervus eurycerus, C. elaphus, C. capreolus, Bos primigenius, Bison priscus, Ursus spelæus, Hyæna spelœa, Machairodus latidens, Canis lupus* and *vulpes*, which already appear in the Forest-beds near Saint Prest, Durfort, etc., as also *Felis spelæa, F. lynx*, some small Rodents and Insectivora. The Pliocene forms, *Elephas meridionalis, Rhinoceros Etruscus*, and *Ursus Arvernensis*, are extinct or, rather, replaced by closely related successors. The entire pre-Glacial and inter-Glacial fauna of Europe required a rich vegetation and a mild climate, which probably corresponded to that of the Mediterranean region of to-day; in no case was it more severe than that of Central

Europe at present. Northern or mountainous forms are still wholly absent; on the other hand the presence of Man is affirmed by the abundant occurrence of rudely worked flint implements of the "Chelléen-type." Whilst this Older Diluvial fauna peopled Europe and Northern Asia, the Ice-Age commenced and evidently destroyed a number of forms which could not adapt themselves to the changed climatic conditions, as *Hippopotamus, Elephas antiquus*, together with its dwarf races (*Elephas Melitensis, mnaidriensis* and *Falconeri*), *Elasmotherium, Trogontherium* and *Machairodus*. An invasion of cold-loving land animals, which to-day find their homes partly in the high North, partly in the rugged Asiatic Steppes, or on high mountainous regions, took place, and they became mingled with the surviving elements of the Older Diluvial fauna. The Mammoth (*Elephas primigenius*) and woolly Rhinoceros (*Rhinoceros antiquitatis*) now reach their maximum distribution, and through the great development of their hairy coats they were perfectly matched to the harsher climate; *Rhinoceros Mercki* also survived, and left behind, as did also both the other species, well preserved bodies in the frozen soil of Siberia. Besides these, the Reindeer (*Rangifer tarandus*) and the Horse belong to the most abundant forms of the Glacial fauna, and with them are found, although less frequently, the extreme northern Musk-sheep (*Ovibos moschatus*) besides boreal forms like the Lemming (*Myodes lemmus*), the collared Lemming (*M. torquatus*), the Voles (*Arvicola nivalis* and *ratticeps*), the Glutton (*Gulo luscus*), the Ermine Stoat (*Putorius ermineus*), the Arctic Fox (*Canis lagopus*), and such Asiatic Steppe-dwellers as the Wild-Ass (*Equus hemionus*), the Saiga Antelope, the Bobak, the pouched Marmots (*Spermophilus*), the Jerboa (*Alactaga*), the tailless Hare (*Lagomys pusillus*), the Shrew (*Myogale moschata*) and forms which live on high mountains, as the Chamois, Ibex, the Alpine Marmot, and the Alpine Hare (*Lepus variabilis*). The majority of the endemic land-mammals which still live in Northern and Central Europe, also formed part of the Glacial and post-Glacial fauna, and all these animals are found, as a rule, mixed up together and washed into rock-fissures and caves which served as dwelling-places for such Carnivora as the Cave-bear, the Cave-hyæna and the Wolf. The Löess also contains the Middle Diluvial Glacial fauna still in great perfection and it is particularly distinguished by the presence of the Mammoth, *Rhinoceros tichorhinus*, Reindeer, Musk-sheep, Deer, Bison and Urus.

After the melting of the gigantic Diluvial Glaciers, certain northern forms, such as Reindeer, Lemming, collared Lemming, Glutton, *Spermophilus, Lagomys* and Jerboa, still maintained themselves for a time in Central Europe, and they characterize the Younger Section (Nehring's[1] period of the Steppe-fauna) of the Palæolithic stage of civilization. The human reliquiæ in the caves of Perigord, of Belgium, of Thayingen and of Schweizerbild near Schaffhausen, and the settlement in the turf of Schussenried in Upper Swabia, furnish excellent instances of the composition of the fauna during the so-called Reindeer period.[1] With the commencement of our present climatic conditions, the Forest-fauna of to-day (Squirrel or Aurochs-period) then spread itself over Central Europe, and with this began the taming and importation of domestic animals by man, and consequently a fundamental change in the composition of the animal surroundings of the men belonging to the Newer Stone period.[2]

---

[1] Nehring A. Ueber Tundren und Steppen der Jetzt-und Vorzeit. Berlin, 1890.

The Diluvial fauna sketched above peopled not only Europe, but also Northern and Central Asia. According to Brandt[3] some characteristic forms are entirely wanting in Asia, as Hippopotamus, Ibex, Chamois, Fallow-deer, Cave-bear and Wild-cat; as against these the Asiatic Diluvial fauna contains *Antilope gutturosa, Capra Sibirica* and *ægagrus, Ovis Argali, Moschus moschiferus, Siphneus Aspalax, Ellobius talpinus, Spalax typhlus, Sminthus vagus, Tamias Pallasi, Mustela zibellina, Felis tigris,* and *Canis Nishneudensis.* Brandt[4] maintains that Northern Asia, and especially the high northern latitudes, form the region where the European, North Asiatic and North American land-faunas had been concentrated during the Tertiary and Diluvial periods, and from whence issued the migrations and forward movements to the South and West, according to the degree in which the colder climate advanced. As the Northern fauna spread itself over more Southern latitudes during the Diluvial period, it occupied the dwelling-places of the forms which had there survived from Tertiary times, it crowded them into sub-tropical and tropical regions, and itself formed the proper stock of the Diluvial fauna.

Although, according to the concordant testimony of Russian geologists,[5] Siberia, in contrast to Europe and North America, was not completely covered by a continuous Ice-sheet during the Glacial period, and only possessed glaciers of limited extension, it nevertheless experienced a deterioration of its climatic conditions and a considerable decrease of temperature, so that only the more readily adaptable constituents of the pre-Glacial fauna were able to maintain their position. Others succumbed to the less favourable conditions of existence, or were obliged to emigrate. The gradual penetration of the frost into the ground and the damming up of the rivers by ice also produced in Siberia, at that time, the conditions for the preservation of entire carcasses of the Mammoth, Rhinoceros, Bison and Musk-sheep.

The Glacial and post-Glacial fauna of North America is much poorer in species than that of Europe; it has, moreover, been less studied, and at times it is difficult to separate it from that of the older *Equus*-beds. As characteristic species may be mentioned, *Mastodon Americanus, Cervus alces, Cervalces Americanus, Rangifer tarandus, ? Cervus Canadensis, Bos Americanus, Ovibos bombifrons, Canis lupus, Ursus ferox, ? Felis atrox.* Noteworthy is the absence of *Equus, Rhinoceros, Hippopotamus, Dicotyles, Sus, Machairodus, Ursus spelæus, Felis spelæa, Hyæna spelæa, Bison priscus, Bos primigenius, Cervus elaphus, capreolus, eurycerus,* and a great number of other forms abundant in Europe and Northern Asia. The Diluvial Mammalian fauna of North America stands in precisely the same relation to that of Europe as the existing faunas of the two continents bear to each other. Identical species are extremely rare; on the other hand the general character is similar, and points to a common origin.

---

[1] Nehring A. Uebersicht über vierundzwanzig mitteleuropäische Quartär-Faunen. Zeitsch. d. deutsch. geol. Ges. 1880, p. 468.

[2] Woldrich, J. N., Die diluvialen Faunen Mittel-Europa's. Mitth. Anthrop. Ges. Wien. 1882, xi.

[3] Brandt, J. Fr. und Woldrich, J. N. Diluviale europäisch-nordasiatische Säugethierfauna und ihre Beziehungen zum Menschen. Mém. Acad. imp. St. Pétersbourg, 1887, vii. sér. xxxv. No. 10.

[4] Naturgeschichte des Elens. Mém. Acad. imp. St Pétersbourg, xvi. pp. 39–50.

[5] Tschersky, J. D. Wissenschaft. Ergebnisse d. Neusibirischen Expedition d. J. 1885 und 1886, iv., Posttertiäre Säugethiere. Mém. Acad. imp. St. Pétersbourg, 1892, xli. p. 455, 511.

In South Asia and South America the Diluvial faunas succeeding those of the Tertiary period consist for the main part of species still existing, but they show somewhat closer ties to their Tertiary forerunners.

From the whole history of Mammalian development, from the Trias to the present time, it becomes definitely evident, in spite of all the deficiencies in the Palæontological record, that the genetical connection between particular faunas, notwithstanding manifold interruptions from geological events, was never completely broken, and that each particular assemblage of animals has been produced by the gradual transformation of its elements from an earlier preceding one, and at the same time it has yielded the seed for that next succeeding. Certain genera (*Didelphys, Sciurus, Myoxus, Sorex*) belonging to the micro-fauna can be traced back into the Eocene, and they have indeed produced new species since their first appearance, but have experienced no transformation worth mentioning, as also the Polyprotodont Marsupials, Insectivora and Rodents, which represent generally the least changeable types of Mammalia. Recent genera of more considerable size make their appearance in constantly increasing numbers from the Lower Miocene onwards, and they partly continue up to the present day.

Our entire animal and plant environment is incontestably rooted in former periods, and in no class of animals does the intimate connection between the past and the present stand out sharper to the view than in the Mammalia.

Concerning their origin and earliest distribution in Mesozoic time there is still wanting, unfortunately, satisfactory information, but the uniformity of the Jurassic Mammalian faunas in Europe and North America, which consist of Allotheria and Polyprotodont Marsupials (or primitive, perhaps marsupial, Insectivora); the appearance of a typical Allotherian genus in the South African Trias; and the great resemblance of the Upper Cretaceous genera to their Jurassic forerunners, make it extremely probable that in the Mesozoic period a single uniform Mammalian fauna peopled Europe (and possibly also Asia), North America and Africa. Whether to this extensive zoo-geographical kingdom Australia also belonged at the same time, or whether, as has often been stated, the Mesozoic forms withdrew themselves there at a later period, cannot, for lack of the needful proofs, be determined with certainty. Under any circumstances the present Australian mammals must in this case have been very radically changed, and they now retain only a few features of their very ancient ancestors.

From the Tertiary period onwards, the distribution of the land mammalia went forth from certainly not more than three areas of development, or so-called 'centres of creation.'

I. The oldest, the earliest separated off from the rest, and still the mostly distinctly bounded of all the zoo-geographical kingdoms, is formed by Australia, with the neighbouring island of Tasmania. In spite of great diversity with regard to climate and meteorology, and in spite of striking differences in the conditions of food support, this kingdom contains the whole of the now existing Monotremata and Marsupials with the exception of the Didelphyidæ, which live to-day in America and in the Tertiary period were also distributed over the whole northern hemisphere; and beyond these only a few forms, probably imported from outside at a later period, such as Bats, Mice (*Pseudomys*, *Hydromys*, *Acanthomys*, *Hapalotis*, *Echiothrix*), and the Dingo, a variety of the domestic dog. According to A. R. Wallace,[1] Australia was already separated from the other continents at the close of the Mesozoic period; moreover, during a portion of Tertiary time it still included New Guinea, Celebes, the Solomon and perhaps also the Fiji islands, and possessed a considerable extension towards the South and West. Even to-day, Australian Marsupials are met with in New Guinea, Celebes, Amboyna, and even in Timor, mingled with Indian placental Mammals. For its connection at one time with South America, the abundant occurrence of fossil Marsupials in the Santa-Cruz beds of Patagonia is valid evidence.

II. The second zoo-geographical kingdom, formerly not less sharply defined than the Australian, is South America or Austro-Columbia.[2] Up to the youngest Tertiary period this kingdom contained only Edentates, Toxodontia, Typotheria, some very peculiarly differentiated Perissodactyla, Hystricomorphous Rodents, Platyrhine Apes, and Marsupials, which, however, very considerably differ from the Australian forms of this group. From this area of development, Africa received, probably at the beginning of the Tertiary period, some scattered wanderers, such as the forerunners of *Orycteropus* and *Manis*, the Hyracoidea, which have perhaps descended from a common root with the Typotheria, and some Hystricomorphous Rodents. But the connection of the South American or Neo-Tropical kingdom with Australia and South Africa, which at one time existed, must certainly have been already again dissolved in the older Tertiary period, for the forms belonging to the same orders in the three continents have had sufficient time to become specialized in an altogether peculiar manner. How at the close of the Tertiary period the Southern and the Northern half of America grew together, and how the faunas of both divisions were mutually pushed over and through each other, has already (pp. 504–505) been sufficiently described.

---

[1] Wallace, A. R., The Geographical Distribution of Animals, 1876.

[2] Huxley Th. Proc. Zool. Soc. London, 1868, p. 316.

III. The third and largest zoo-geographical kingdom, the Arctogæan, includes not only Europe, Asia, and Africa, but also North America. Although all Palæontological traditions respecting the older Tertiary period in Asia and Africa are up to now still wanting, nevertheless, neither the prolific Mio-Pliocene mammalian fauna of Asia, nor the scanty remains from the younger Tertiary formations of Africa, nor the composition of the still existing fauna of South Asia and Africa, can give rise to even a suspicion that along with the known Mammalian races in the older Tertiary of Europe and North America, there could have originated yet another heterogenous fauna in any part whatever of Eurasia. The Tertiary forms of Europe and North America, known up to the present, completely suffice to show that the Mammals of Europe, Asia, Africa, and North America are derived from them (with the exception of some forms conjectured to have wandered from Australia and South America). The Palæarctic, Nearctic, Ethiopic and Indian kingdoms of Sclater and A. R. Wallace form for the Mammals (as Huxley has already pointed out) a single distribution region, which indeed, during the Tertiary and Diluvial periods became already split up into several provinces. The connection with North America was the earliest to be loosened, and already in the Miocene and Pliocene, the New World stood, as against the Old, as an independent zoo-geographical province; which, indeed, after the Ice-age, again received some northern guests, probably from Eastern Asia. To Southern Asia and Africa a portion of the heat-loving animals, especialy Ungulates, Carnivora and Apes, withdrew themselves at the close of the Tertiary period and peopled a province which reached from the West Coast of Africa as far as the Chinese Sea, and may still further have embraced the coast districts of the Mediterranean Sea. In the newer Tertiary period, Ceylon, the Sunda Islands, the Philippines, and Madagascar certainly stood in connection with the neighbouring continents, and received from these their supply of land Mammals. Africa and South Asia even now possess a number of genera in common, and they contain, strictly taken, a single mammalian fauna which probably as late as the Diluvial period became so far differentiated that it can to-day be divided into two independent provinces. Madagascar, with the Mascarene Islands, maintains the same rank as the Indian and Ethiopian provinces. The land Mammals of this small region display unmistakable features of a great isolation at an early period. Excepting the Swine, and some small, as a rule, passively wandering Rodents, most of the Mammals belong to peculiar, specifically Madagascar genera. The numerous Lemurs call to mind their Upper Eocene forerunners in Europe, and even the Carnivora (Cryptoproctidæ) and Insectivora (Centetidæ) point to ancestors in the older Tertiary. Indigenous Ungulates are wholly absent in this Island region.

In contrast to this ancient (Madagascar) province, Europe and Northern Asia (the so-called Palæarctic region) possess the youngest Mammalian fauna. This first became modified in the Diluvial period, probably under the influence of the Ice-age, and it gradually received a character different from that of the Ethiopic-Indian fauna. Whether also Man, the most youthful figure in the animal world, has originated within this youngest fauna, or whether his cradle, as Ameghino believes, must be sought for in another portion of the world, cannot be provisionally determined with certainty.

VI.—NOTE ON *MYALINA CRASSA* (FLEMING).

By WHEELTON HIND, M.D., F.R.C.S., F.G.S.

THE genus *Myalina* was erected by Prof. De Koninck, in his Description des Animaux fossiles qui se trouvent dans le terrain Carbonifère de Belgique, for certain Modioliform shells, and M'Coy re-defined the genus in his British Palæozoic fossils and described two forms from the Permian of Durham.

King, "Permian Fossils," describes the same two shells under *Mytilus*, but in the text discusses the propriety of placing them in De Koninck's genus *Myalina*. The characteristic points of this genus to which I wish to draw attention are the presence of triangular septa in the beaks (Myophores), which are shown in casts as deep slits beneath the beaks, umbones terminal, a flattened bevelled striated hinge-plate; all of which characters are shown in King's figures, Palæontograph. Soc. vol. iii. 1849, Mon. "Permian Fossils," pl. xiv. figs. 1 to 13.

So much, then, for the characters of *Myalina*. Now, in the Ann. and Mag. Nat. Hist. series iv. vol. xv. 1875, is a paper on *Myalina crassa* by Mr. R. Etheridge, jun., where he describes a shell, obtained from various localities in the Lower Carboniferous of Scotland, under this name, and gives five beautiful figures, four of which show the hinge-plate or interior.

On reference to these it will be noted at once that in this shell the umbones were not terminal, and they possessed no rostral plates, and in his complete and perfect description he says: "Beaks not quite terminal." "Anterior end forms a small lobe in front of the beaks and umbonal ridges." "Anterior adductor impression double pit-like and deep-placed within the umbonal cavity." It is nearly always treble.

I have had this year the opportunity of examining more than a hundred specimens in museums and at the locality given for the shell by Mr. Etheridge, Cults Lime Works, Pitlessie, and while agreeing in every important detail with his masterly description I cannot understand why he placed the shell in the genus *Myalina*, as it differs so entirely from the typical members of that group in the Permian.

This shell was originally described by Fleming in the Edinburgh

Phil. Journ. 1825 as *Modiolus sp.*, and in 1828 in his British Animals as *Mytilus crassus*, and was referred by King, "Permian Fossils," p. 159, to *Myalina*, in which he was followed by Huxley and Etheridge, Cat. Foss. Mus. Pract. Geol. p. 110, 1865; by Armstrong and Young, Cat. Carb. Foss. W. Scot., 1871; Capt. Brown referred to it as *Avicula*, Foss. Conch., 1849.

Salter, in Geol. Surv. Mem. Iron Ores of S. Wales, p. 228, in mentioning those Mytiliform shells now known as *Anthracoptera*, hazarded the name *Myalina*, which he subsequently altered to *Anthracoptera*, Geol. Surv. Mem. Country around Wigan, 1862, on account of the "absence of the striated hinge-plate of *Myalina*," a character which I have shown (Quart. Journ. Geol. Soc. vol. xlix. 1893, pl. vii. figs. 1, 1*a*, 1*b*, 2, 2*a*) they possess.

And indeed there is no one anatomical point in the shells of the so-called *Myalina crassa* which differs from those of *Anthracoptera*.

Meek and Worthen, in the Geological Survey of Illinois (Palæontology), refer the Mytiliform shells of the Coal-measures to *Myalina*, and Barrois, in his "Recherches sur les terrains anciens des Asturias et de la Galice," p. 334, remarks on the close resemblance between *Anthracoptera* (Salter) and *Myalina*, and thinks it impossible to distinguish between them. He describes *Myalina triangularis* and *carinata* from Spanish beds, and considers that *Myalina* is synonymous with *Anthracoptera*.

The *Myalina crassa* and various forms of *Anthracoptera* belong therefore, I believe, to the same genus, which I think can be separated from the true *Myalinas* of the Permian by the absence of rostral myophores and the umbones not being terminal.

I propose to substitute the name *Anthracoptera crassa* for that of *Myalina crassa*. The fauna of the bed in which it occurs at Cults is interesting, bearing on the salt or brackish origin of these beds. I find it associated there with *Spirorbis carbonarius*, *Stigmaria*, scales of *Megalicthys*, rolled corals, *Zaphrentis*, *Aviculopecten* and Encrinite remains. Mr. Etheridge mentions its occurrence with *Schizodus* and other marine forms at other places in Scotland.

I am able to give another locality for this shell, viz. Beith, Ayrshire, on the authority of Messrs. Young and Armstrong.

REVIEWS.

I.—TRANSACTIONS OF THE SEISMOLOGICAL SOCIETY OF JAPAN, vol. xvi. 1892. pp. 120.

Contents:—(1) C. A. W. Pownall: Notes on recent publications relating to the effect of earthquakes on structures, 1. (2) C. A. W. Pownall: Appendix to the above notes, 14. (3) S. Sekiya and F. Omori: Comparison of earthquake measurements made in a pit and on the surface-ground, 19. (4) J. Milne: A mantel-piece seismometer, 47. (5) W. K. Burton: Notes on seiches observed at Hakone Lake, 49. (6) F. Omori: A note on diagrams from seismographs recording vertical motion, 53. (7) J. Milne: [Epitome of the] Report of the Chirikioku (Meteorological Department) in Tokio on seismometrical observations made in Japan during the year 1888, 55. (8) J. Milne: ditto, during the year 1889, 81. (9) Obituary notice, His Majesty David Kalakaua, 119.

THE SEISMOLOGICAL JOURNAL OF JAPAN. Vol. i. 1893 (corresponding to Transactions of the Seismological Society, vol. xvii.): edited by Prof. J. Milne, F.R.S. pp. 151

Contents:—(10) J. Milne: On the investigation of earthquake effects and certain experiments in earth physics, 1. (11) W. K. Burton: On the application of photography to seismology and volcanic phenomena, 21. (12) J. Milne: Seismometrical observations for the year 1890, 31. (13) J. Milne and F. Omori: On the overturning and fracturing of brick and other columns by horizontally applied motion, 59. (14) J. Milne: Earth pulsations in relation to certain natural phenomena and physical investigations, 87. (15) J. Milne: On the movements of horizontal pendulums (an abstract, with notes on observations made by Dr. E. von Rebeur-Paschwitz), 113. (16) F. Omori: A note on early Chinese earthquakes, 119. (17) J. Milne: A note on the great earthquake of October 28th, 1891, 127.

The Seismological Society of Japan was founded in 1880 and ceased to exist in 1892, having in the interval issued sixteen volumes of Transactions, which are known and valued wherever earthquakes are studied. Their publication, indeed, formed the principal work of the Society, and, when latterly the attendance at the meetings declined from various causes, scarcely any break of continuity occurred when the Society was dissolved and the Transactions were replaced by the Seismological Journal. It will be seen that in the new work, as in the old, Prof. Milne is the chief contributor, and one can hardly wish that he should be spared the labour of much writing. But that the cost of its production should also fall upon him is greatly to be regretted, and, unless that burden is removed, it would be too much to expect that the publication of the Journal will be very long continued.

Some of the work described in the two volumes above mentioned is already known in this country through Prof. Milne's admirable reports to the British Association. The last paper, for example, is reprinted with the addition of a few lines from the report read at the Edinburgh meeting, and in the same volume will be found summaries of the papers numbered above (7), (8) and (13). A reference to the more important of the remaining papers will, therefore, be sufficient here.

(3) It has frequently been noticed that earthquakes are felt more strongly on the surface than at the bottom of mines, and, for severe earthquakes, the commonly received opinion is supported by some observations made by Prof. Milne in 1884 and 1885. These have been continued by Messrs. Sekiya and Omori, and, in a very interesting paper, they have described their results so far as regards the horizontal component of the motion. The observations were made in a pit, 4 feet square and 18 feet deep, and situated only a few yards from the seismological observatory of Tokio University. The soil is hardened alluvium, and the bottom of the pit is paved with brick to a depth of two feet. On this were placed a pair of Prof. Ewing's horizontal pendulum seismographs in E.—W. and N.—S. directions, so that their records could be compared with those of similar instruments on the surface. Between January 15th, 1887, and April 18th, 1889, the records of thirty earthquakes were collected, three of them being severe shocks, and the remainder slight ones

like those which are felt almost daily in Japan. In the following table are given the average ratio (mean of both components) of the amplitudes (A), periods (B), maximum velocities (C), and maximum accelerations (D), as observed on the free surface ground to those observed in the pit:

	A	B	C	D
Slight earthquakes	1·2	1·0	1·3	1·6
Severe earthquakes, large undulations	1·4	1·1	1·3	1·3
Severe earthquakes, ripples	2·2	0·8	2·8	4·7

These figures show that, for small earthquakes and for the principal undulations of severe earthquakes, there is not very much difference between the surface and underground observations; but that the difference is considerable for the ripples or small quick vibrations which precede and are superposed on the larger waves. In severe earthquakes these ripples are very prominent, and, being very quick in period though small in amplitude, their maximum accelerations, and consequently their overturning and fracturing effects, are very much greater than those of the principal waves. In the pit, these ripples are in part smoothed away, and their average maximum acceleration is only about one-fifth that of the ripples recorded on the surface. It thus appears that in times of severe earthquakes, there should be less destructive action in deep pits than on the surface of the ground.

(10) This paper deals chiefly with the construction of buildings in earthquake countries. Perhaps the most interesting part is that which relates to the possible issue of earthquake warnings. Previous attempts in this direction have failed, but Prof. Milne justly urges further inquiry before we relinquish what may seem an impossible task. The plan he suggests at all events appears worth trying. Starting with the hypothesis that "earthquakes are the result of faulting, and that faulting is due to a bending of the earth's crust beyond its limits of elasticity," he proposes that a very long water-level should be placed at right angles to an axis of elevation, or, better, two such levels at right angles to one another. It might thus be ascertained whether secular changes of level are measurable by such an apparatus, and, if so, whether they are in any way connected with the occurrence of earthquakes.

(14) One of the subjects which have been studied most closely by Prof. Milne is that of earth-pulsations. Several instruments have been used by him, levels, tromometers of various lengths, pendulums, whose movements have been magnified in different ways and also made self-recording, and finally a conical pendulum, of which a description will be found in the British Association Report for 1892 (pp. 107–8). In his earlier work, Prof. Milne discovered that a connection exists between earth-pulsations and local or distant winds. His later researches show that there is a still closer connection with the barometric gradient. With high gradients pulsations have always occurred, and with moderate ones they have generally been present. They are also most frequent during the winter season, when the barometric gradients are steepest. Prof. Milne considers that these pulsations are long flat waves of various amplitudes and

lengths, not altogether unlike the swell upon an ocean. In period they range from one to four or five seconds, their maximum slope being roughly from 1 in 200,000 to 1 in 40,000, *i.e.* from about 1″ to 5″. He believes that they may be due to fluctuations in atmospheric pressure, acting over considerable areas of the earth's crust, not necessarily taking place at the spot where the fluctuations are observed; for, as he shows, the pulsations if produced in this manner might outrace their cause. Towards the end of the paper, Prof. Milne discusses the possible connection of earth-pulsations with the rate of escape of fire-damp in mines. He also shows that the zero of a delicate balance may be temporarily altered by earth-pulsations, and that consequently in weighing by the "method of vibrations" the results may be slightly inaccurate. In the same way, errors may perhaps occur in pendulum experiments and in the delicate work of astronomical observatories.

(16) Mr. F. Omori summarizes the accounts which he has collected from histories and chronicles of 908 shocks, or groups of shocks, felt in China previously to the year 1644. Two districts are especially characterized by earthquakes, one consisting of the three northern provinces of Kansu, Shense, and Shanse, which have often been the seat of extensive and violent earthquakes; the other, the south-western province of Yünnan, where the shocks are mostly local. These Mr. Omori considers to be distinct seismic regions, for they show no coincidence in their epochs of maximum disturbance. The meizoseismal area of several earthquakes, he finds, was an elongated valley tract, and in such cases the disturbed area was generally extended in a perpendicular direction.

C. Davison.

II.—Palæontology of New York, Vol. VIII. Part II. Fascicle I. An Introduction to the study of the genera of the Palæozoic Brachiopoda. By James Hall, assisted by John M. Clarke. Albany, New York, July, 1893. (Charles Van Benthuysen & Sons.)

Owing to unavoidable delay in printing the lithographic plates designed to accompany the second volume of Hall and Clarke's monumental work on the genera of the Palæozoic Brachiopoda, the authors deemed it advisable to issue a part of the edition in the form of fascicles. The first of these was published in July last and treats exclusively of the spire-bearing genera. It contains 176 pages of text, accompanied by numerous woodcuts, and although it lacks the illumination of the plates we welcome its appearance gladly as a further instalment of the excellent work that has already effected a revolution of thought in the world of brachiopodists.

The method and text of the first fascicle of the second volume are as excellent as those of the first. The subject-matter called for less rigorous treatment, as the various spire-bearing forms had been carefully investigated by Dr. Davidson, by the light of the Rev. Norman Glass's excellent preparations of the variously modified spiral calcified supports of the brachial organs. The Carboniferous species of India had also been well described and illustrated by Waagen, and the post-Palæozoic genera, comparatively few in number, by Bittner and other authorities. So that ample material awaited the New York palæontologists, who have now given us a complete survey of this interesting group of fossil Brachiopoda, with special reference to the American species.

The authors commence with the variable and numerous species of the genus *Spirifer*, of which they concur in recognizing Martin's *Anomites striatus* as the type. About two hundred American Palæozoic species are recorded and subjected to careful comparison and revision. They are held to be all congeneric, and the species are therefore (not for the first time in the history of the genus) classed in groups in accordance with the manifold external variations and salient features of an ornamental character.

This method of comparison leads the authors to formulate the novel and highly suggestive conclusion "that these external differences make an excellent basis for a grouping of the members of this protean genus, and one not merely conventional and arbitrary, since it serves to indicate, within the integrity of the genus, lines of progress leading to resultants which are no longer congeneric" (p. 11).

We summarise the classification they propose of six main groups of species, viz.:

I. Radiati. A primitive type with few, many, or double plications, of which *S. radiatus*, including *S. plicatellus*, Sby., are held to be typical examples.

II. Lamellosi. *a. Septati*, with a median septum in the pedicle valve. *S. permallosus*, Hall, is given as a typical example.
  b. Aseptati, without median septum, *S. mucronatus*, Conrad, and *S. sub-mucronatus*, Hall.

III. Fimbriati. *a. Unicispini*=*Delthyris*, Dalman, *sensu stricto*, with short, simple, hollow spines, such as *S. crispus*, Hisinger.
  b. Duplicispinei = *Reticularia*, M'Coy, with large compound spines, often with lateral branches, of which *S. fimbriatus*, Conrad, is the earliest example from the Hamilton group, *S. lineatus*, Martin, a well-known Carboniferous form.

IV. Aperturati. Forms with plications on the sinus fold and sinus, of which *S. aperturatus*, Schlotheim, *S. disjunctus*, Sby., and *S. striatus*, Martin, are cited as typical examples.

V. Ostiolati. Median fold and sinus without plication, such as *S. ostiolatus*, Schlotheim, *S. Oweni*, Hall. These are the syringothyroid spirifers.

VI. Glabrati. Smooth shelled species sub-divided into:
  a. Aseptati=*Martinia*, M'Coy, type *S. glabra*, rare in America.
  b. Septati, with dental plates or septa well developed, again subdivided into:
  1. *Martinopsis*, Waagen's genus, for species with lamellæ in both valves, from the Productus limestone of India.
  2. *Tschernyschew*, type *Martinia semiplana*, Waagen, for shells with a prominent median septum in the pedicle valve and dental lamellæ scarcely developed.

Messrs. Hall and Clarke consider, however, the latter as probably congeneric with Quenstedt's genus *Mentzelia* (*Spirifer medianus*), from the Silesian Muschelkalk. They hold them to be connected with the post-Palæozoic members of the genus *Spiriferina* from the presence of the median septum, and associated with the glabrate *Spirifer* on account of the punctation of the epidermal layer of the shell: This classification of the American species of *Spirifer* is presented in a convenient tabular form, with time limits of species indicated, and will stand examination better when it can be compared with the plates destined to illustrate the volume.

Dalman's genus ? *Cyrtia* and Davidson's *Cyrtina* are retained. The latter comprises the first indication of shell puncture among the Spiriferoids. Winchell's genus, *Syringothyris*, is considered as defining species "outcome from Spirifer along the line of the Ostiolati," while D'Orbigny's *Spiriferina* covers species with characters derived from the lamellose-septate Spirifers dating from Upper Silurian times. The genus *Ambocœlia*, Hall, is a small spire-bearing Devonian type, and his new genus *Metaplasia* is proposed for a little shell originally described as *Spirifer pyxidatus*, but not yet proved to be a spire-bearer, while its external form recalls that of *Orthis*. It is somewhat allied to *Spirifer cheiroptyx*, D'Arch. and De V., from Paffrath, and to *S. Oceani*, D'Orb., from the Carboniferous limestone of Visé, and for this aberrant group Hall and Clarke suggest the designation *Verneuilia*. The term *Whitfieldella* is proposed for certain forms of Meristoids, of which *Atrypa nitida*, Hall, is taken as the type, hitherto described as *Meristina*, that generic name being now restricted "to species similar to *M. Maria*, Hall, which these authorities do not consider to be specifically identical with *Atrypa tumida*, the tpye of Davidson's non-acceptable genus *Whitfieldia*, a synonym of *Meristina*.

In all, Hall and Clarke now recognise forty-eight genera of Palæozoic spire-bearing Brachiopoda, of which twelve new genera and subgenera are now described and figured by the authors for the first time. Twelve others have been admitted as valid by various authors since Davidson's Summary and Appendix was published in 1884. The claims of a few others, such as King's genus *Cliothyris*, type *Athyris pectinifera*, *Actinoconchus*, M'Coy, (*Athyris planosulcata*) and *Seminula*, M'Coy (*A. ambigua*), are readmitted, and the balance remain much as Davidson defined them, with the exception of his genus *Bifida*, which the American palæontologists regard as synonymous with *Anoplotheca*, Sandberger, and *Anazyga*, Dav., based on *Atrypa recurvirostra*, which is merged in *Zygospira*, type *Producta modesta*, Say. The divergent *position* of the loop is shown to be a matter of individual variation, of which *Zygospira modesta* and *Z. recurvirostra* (*Anazyga*) represent "extreme possibilities of variation." Winchell and Schuchert's supposed primitive terebratuloid genus *Hallina* is also referred to *Zygospira*, which seems to be represented by numerous species in the Trenton, Hudson River group and Niagara shales of America.

We subjoin a list of the new genera proposed by Hall and Clarke with the types on which they are founded.

Metaplasia, type *Spirifer pyxidata*, Hall. Whitfieldella *Atrypa nitida*, Hall. Hyatella, type *Athyris junia*, Billings. Camarospira, type *Camarophoria eucharis*, Hall, for shells essentially meristoid, but differentiated by "greater convergence of dental plates which restrict the impression of the pedicle muscle to a distinct chamber or spondylium."

Ptychospira, type *Terebratulata ferita*, Von Buch.

Hustedia, type *Terebratula Mormoni*, Marcou, from the Upper Carboniferous. The authors consider that various species from the Alpine Trias referred to *Retzia* by Bittner, are closely related to this genus.

Parazyga (*Atrypa* or *Trematospira hirsuta*), Hall.

Anabia, type *Anabia Paraia*, Clarke.

Cyclospira, type *Orthis bisulcata*, Emmons. It is "closely allied by external form to *Dayia navicula*, but differs so widely in internal structure that the two species appear to be but remotely related to each other."

Protozyga, type *Atrypa exigua*, of which the *Zygospira aquila*, Sardison, and *Hallina Nicolleti*, W. and S., are synonyms.

Catazyga is a subgenus founded on *Athyris Headi*, Billings, and in Clintonella we have a genus based on a new species, *C. vagabonda*, from the Clinton group.

Atrypina, type *Leptocœlia imbricata*, Hall, from the Lower Helderberg series, is an interesting genus including several small Atrypoids which foreshadow the *Atrypas* of the reticulated type of *A. reticularis*, to which the American palæontologists would restrict that generic appellation. These seem to have been "not derivatives of the yoked spire-bearers *Zygospira* or *Catazyga*, but to have developed in a line essentially parallel with those genera," and to have originated from a common ancestor (p. 111).

Hence it is evident the authors suggest some interesting points for discussion, and throw further light on the evolution of the Brachiopoda by their careful studies of the spire-bearing group from the ancient rocks of America. The completion of their researches on the Rhynchonelloids and early Terebratuloids will be awaited with interest by all students of the Brachiopoda, who cannot fail to recognize the value of Professors Hall and Clarke's laborious, painstaking, and most fruitful researches.

Agnes Crane.

III.—The Geology of the Southern Transvaal. By W. H. Penning, F.G.S., etc. 8vo. pp. 37. E. Stanford (London, 1893).

This memoir has been prepared to accompany Mr. Penning's Geological Map of the Transvaal Goldfields, published by E. Stanford, and based on the author's researches, as given in detail in several papers in the Journ. Soc. Arts and Quart. Journ. Geol. Soc. in 1884–91. It unites the four gold-bearing localities, the De-Kaap and Lydenburg, the Rand and Klerksdorp, an area about 450 miles long, by 50 in breadth, comprising some 22,500 square miles. This has been geologically coloured, as correctly as circumstances have permitted, on an existing map; and it appears to carry out the author's views (1) that the main gold-bearing rocks are siliceous deposits laid down as sandstones and conglomerates in water of some sort; (2) that, though folded in some places, they dip regularly downwards, at least near Johannesburg, and then for about 150 miles they at first strike E., dipping S., then S.E., dipping S.W., then S., dipping W., and then westwardly with a northerly dip, to form one rim of the basin of which the northern rim is the Witwatersrand; (3) that the beds are thus continuous underground from rim to rim, some series of beds varying in their persistency, and thus differing in their gold-bearing qualities; (4) that gold was deposited chemically from the water which moved and deposited the pebbles mainly constituting the "bankets." The thickness of the Witwatersrand beds near Johannesburg (the lower part of the series) is estimated at about 17,000 feet; and, the outcrops being known in some cases, and the underground position and lie of the beds in others, calculations can be made as to the probable extension and depth of the beds in the several mines and borings.

Other features besides the "bankets" are succinctly treated of, with a personal knowledge of the geography and geology, the chief rivers, valleys, plateaux, and mountains being mentioned. Of the geological formations occurring in the Southern Transvaal, besides (1) Recent Alluvium, (2) the River-gravels of the present streams, and (3) those of the older valley-systems, the following are indicated on the Map, in downward succession: (4) the High-Veldt Beds, in the lower part of which are coal-seams of some value exposed in the valleys; (5) the Kimberley Beds; (6) Bedded felspathic Trap-rocks; (7) Upper Witwatersrand Beds; (8) ? Bedded felspathic Trap-rocks; (9) Lower Witwatersrand Beds, or "Banket" formation; (10) De-Kaap Valley[1] Beds; (11) Granite and Granitic Rocks.

The De-Kaap rocks near Barberton, at 8 sections, are first described; the Lower Witwatersrand rocks at 29 sections, those of the Upper series at 11 sections; and others are referred to. The much faulted area of the Lower series at Leopard's Vlei is shown by a plan at page 21. A separate plan of the Witwatersrand Goldfield, on a scale of 10 miles to 1½ inches, is given on the Map.

The thick limestone (dolomite?) into which the Mooi River burrows at Wonderfontein seems to be included in the Upper Witwatersrand series, and some particulars of its character and range would have been of interest to geologists.

The Kimberley Beds and the coal-bearing beds of the High-Veldt formation are briefly noticed, with accounts of two sections (Boksburg and Brakpan), and reference to former papers on the subject. Some remarks on the well-known great denudation of the country and its alluvial deposits are appended.

---

[1] The Valley of the De-Kaap River is here intended; and that better name is retained by the author once, at page 26, as in the Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 569, etc., and vol. xlvii. 1891, pp. 451, etc., pl. 15.

Mr. Penning's map here noticed, and its explanatory brochure, are welcome additions to our knowledge of the Geology of South Africa.

NOTE.—It may be added that the output of gold from the Witwatersrand mines was stated by the Chamber of Mines at Johannesburg to have been in May, 1893, 116,911 oz. 15 dwts., valued at £411,877 (at about £3 10s. an ounce); in June the output was 122,907 oz.; in July 126,169 oz.; and in August 136,069 oz., valued at £476,319.

IV.—MONOGRAPHS AND BULLETINS OF THE UNITED STATES GEOLOGICAL SURVEY.

ANOTHER batch of these most useful and valuable publications has just reached this country.

Monograph xvii., "The Flora of the Dakota Group," is a posthumous work of Leo Lesquereux, edited by F. H. Knowlton, who, in his preface, gives some interesting details in the life of the author. The work was undergoing final revision by Lesquereux when he died, and it has been yet further amplified by the editor, thus making it the most complete monograph on the subject, and rendering the Flora of this group one of the most thoroughly known to palæobotanists.

Monograph xviii., "Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey," by R. P. Whitfield, is a second contribution to the palæontological knowledge of these beds, the Brachiopoda and Lamellibranchiata having formed the subject of Monograph ix. (1885). The material dealt with proved very unsatisfactory, consisting largely of casts, which render the determination, even of genera, most difficult, and though no pains were spared by the author his task is not yet completed, and it is to be hoped that in future he will meet both with better material and a better artist, for, with the exception of certain of the Cephalopod plates, the drawings are decidedly flat.

Monograph xix., "Geology of the Eureka District, Nevada," with an Atlas, by G. A. Hague, includes a special paper on the "Microscopical Petrography of the Eruptive Rocks of the Eureka District," by J. P. Iddings, and a "Systematic List of fossils of each formation in the Eureka District," by C. D. Walcott. The Palæontology of the district was treated of in Monog. viii. by Mr. Walcott, and its Silver-Lead deposits in Monog. vii. by Mr. Curtis. The present work is purely geological, and is a very careful study and survey of a small tract of hitherto unmapped country.

The bulletins to hand include a series of the useful correlation papers: No. 82 Cretaceous, 83 Eocene, 84 Neocene, 85 the Newark system, and 86 Archæan and Algonkian (in which last are included "all recognizable pre-Cambrian clastics, and their equivalent crystallines").

The sole palæontological number is 93, devoted to an account of "Some Insects of special interest from Florissant and other points in the Tertiaries of Colorado and Utah," by S. H. Scudder, who records the first discovery in America of a fossil Gomphina (*Stenogomphus carletoni*, n.g. et sp.), of a fossil *Cicada* (*C. grandiosa*, n. sp.) of large size, with other new genera and species of fossil Insects, including a bot-fly (*Palæstrus oligocenus*, n.g. et sp.), who, in the absence of the Mammalian families at present most subject to the attack of its descendants, probably devoted its attention to the Tylopoda.

"The Record of North American Geology for 1890" (No. 91), carried out on the same excellent lines as it predecessors, and a "Report of work done in the division of Chemistry and Physics" (No. 90), are the most important of the remaining bulletins; the other subjects being: "The compressibility of Liquids" (No. 92); "The Mechanism of solid Viscosity" (No. 94); "Earthquakes in California in 1890 and 1891" (No. 95); "The Volume Thermodynamics of Liquids" (No. 96).

V.—PALÆOSPONGIOLOGIE. Von HERMANN RAUFF. Erster Theil. 1te—4te Lieferung. Mit 48 Abbildungen. Palæontographica, Bd. XL, 1893, pp. 1–232. Stuttgart.

THROUGH the efforts of numerous authors within the last twenty years to amend the description and classification of fossil Sponges, the discredited position which this group sustained for such a long time previously has now been to a great extent redeemed, and it may be said to-day that our knowledge of the fossil, as compared with that of the recent forms, is quite on a par with that of any other class of animals. The modern method of study of the fossil forms initiated by von Zittel, not only opened the way for their reconstruction on a natural basis, but it also reacted on the work done amongst the recent forms as well, and supplied important clues to a proper understanding of their nature and relative position. By a fortunate coincidence this new work on fossil sponges took place at a time when the Challenger and other expeditions brought to light, from great depths of the ocean, a number of living sponges, previously unknown to science, which proved to be related to the groups most numerously represented in cretaceous and other rocks. The description of these recent deep-sea sponges has contributed much fresh knowledge of their characters, and thereby also added to that gained already respecting their fossil relatives, and this, together with the increased amount of recent work amongst the fossil forms, furnishes a wealth of material for a general treatise on these organisms from a palæontological point of view. Such a work, we are glad to report, has been undertaken by Dr. H. Rauff, of Bonn (a former student of Prof. von Zittel), and the first four parts, now before us, which are being issued in the "Palæontographica," show that the subject is being treated in a fuller and more comprehensive manner than has hitherto been attempted.

In the introductory or general part, a chronologically arranged list of papers relating to fossil sponges, to the number of 592 is given, followed by another list containing the author's names in alphabetical order, the titles of their papers, and the particular geological horizons of the sponges described in them; which will materially facilitate the hunting out of references. Next comes a long chapter on the literature of the group, in which the various views and systems of different authors are explained and discussed. It is somewhat depressing to see from this what a large amount of earnest labour has been wasted, on what we now recognize to be thorough failures to understand the real nature of these organisms, and this groping in the dark lasted to pretty well up to 1876.

Succeeding chapters treat of the Morphology, the Histology (as known from living forms) and the Canal system in fossil sponges, and the author describes nine different modifications of the canal system as shown by the skeleton. The mode of increase is then referred to, and the puzzling question as to what constitutes an individual or a colony. Next comes the important subject of the nature and form of the various kinds of spicules in siliceous and calci-sponges, and the mode of their union in the case of the former of these.

In the classification the author considers the Sponges, as a whole, to belong to the Metazoa rather than to a separate sub-kingdom. Four orders of siliceous sponges are recognized, 'Hexactinellida, Tetractinellida, Monactinellida, and Ceratosa.' This last may be neglected, since no fossil forms belonging to it are as yet known, and of the other three it may be said that palæontologists are mainly concerned with only two groups, the Hexactinellids and the Lithistids, since with rare exceptions, all the forms of fossil siliceous sponges are included in them, though we know from the abundance of the detached spicules of Monactinellids and Geodine Tetractinellids that sponges of these divisions were probably as numerous in the past as at the present day. In one or two points the classification put forward is open to criticism, thus for example, the Placospongidæ, with their dermal crust of globate spicules, quite undistinguishable from those of the Geodine Tetractinellids, are yet reckoned as Monactinellida; and there is much to support the view that most of the other families placed in the tribe Clavulina have a good claim to be considered as modified Tetractinellids.

As regards the Calcisponges, the author ranks all the known forms, fossil and recent—with one exception—under a new order, the Dialytina. The solitary exception is a very remarkable new form from the coast of Japan, at present very briefly described and not yet figured, which Dr. Doderlein states has the spicules connected together in the same way as in the siliceous Lithistids. This new form stands as the only representative of the order Lithonina.

There is one particular feature in this work to which exception may be taken, and that is the excessive use of terms taken from the Greek to designate the various forms and parts of spicules. In this matter Dr. Rauff may plead that he has followed the example of some of the principal writers on recent sponges during the last few years, who have agreed to cast aside, with very few exceptions, all the terms previously employed in spongiology and replace them by new Greek ones. To make matters worse, these authorities are not always agreed as to the most suitable Greek words to employ, though they seem to consider the vernacular unsuitable even for the simplest forms of spicules. As an illustration of the peculiar language current amongst leading spongiologists the following description of a simple spicule is taken from one of the "Challenger" Reports on Sponges:—"Tylotoxea. The esactine of the rhabdus is tylote and the ecactine oxeate." It will hardly be believed then when interpreted into English this sentence only means that the spicule is pin-shaped, having a knob or head at one end and tapering to a point at the other. The true interests of science are hardly likely to be advanced by such a pedantic employment of Greek, but it is a very effectual method of darkening knowledge and restricting it to a very select circle of Illuminati. We do not in the least wish to impute that Dr. Rauff or other authors use the Greek with such a purpose; they will probably allege that only in this way can a scientific nomenclature be obtained.

In conclusion we desire to express our hearty appreciation of the thoroughness and accuracy of Dr. Rauff's work and of the service he is rendering to palæontology; and we anticipate with much interest the appearance of the remaining portions of this Monograph.

CORRESPONDENCE.

CONCENTRIC LAMINATION AMONGST THE PEBBLES ON NORTHAM RIDGE.

Sir,—Owing to an insufficient index I unfortunately missed Mr. Townshend Hall's paper on the above subject in the "Transactions of the Devonshire Association," vol. iv. p. 433. Mr. Hall maintains that the lamination "has been produced by the effects of the long-continued hammering and pounding which the pebbles have received one from the other." While regretting my oversight, I cannot but rejoice that these curious cases of lamination by pressure in the form of percussion have been so well attested. A. R. Hunt.

Torquay, *Oct.* 10*th*, 1893.

OBITUARY.

EDWARD CHARLESWORTH, F.G.S.

Born September 5th, 1813. Died July 28th, 1893.

There has lately passed away from the geological ranks one who for many years was a prominent figure at the meetings of the Geological Society and the Geologists' Association.

Edward Charlesworth was born at Clapham, Surrey, on the 5th September, 1813. He was the eldest son of the Rev. John Charlesworth, M.A., rector of St. Mildred's, Bread Street, London, and grandson of the Rev. John Charlesworth, a Fellow of Trinity College, Cambridge, and vicar of Ossington.

Mr. Charlesworth's father was much interested in geology, through the influence of Prof. Lambert, and at an early age he imbibed a strong taste for collecting fossils, which became the ruling passion of his life.

He was educated at a private school by the Rev. W. Kitchin, rector of Nedging and Norton, Suffolk, and father of the present

Dean of Winchester. At an early age he was articled to an eminent London physician and later on entered Guy's Hospital as a student; but, having a distaste for medicine, he abandoned it and turned his attention to scientific subjects, especially to geology.

When only 22 years of age he published a masterly paper "On the Crag-formation and its Organic Remains" (Phil. Mag. vol. vii. 1835, pp. 81–94). He therein pointed out that the Crag of Suffolk was divisible into two parts, which he termed respectively the "Coralline" and the "Red Crag." These divisions were accepted by Lyell, and they have now become permanently established. He subsequently pointed out that the Crag of Norfolk formed a newer division, which he named the "Mammaliferous Crag"; but to this bed the term "Norwich Crag" is now generally applied.

In 1835 Mr. Charlesworth was elected a Fellow of the Geological Society of London, and remained a Fellow up to the time of his death—nearly sixty years.

In the same year (1835) he was elected an Honorary Curator of the Ipswich Museum, where some of his early collections of Crag fossils are still preserved. He read a paper "On the remains of Vertebrate animals found in the Tertiary beds of Norfolk and Suffolk" before the Geological Section of the British Association at Bristol, in 1836, presided over by Prof. Dr. Buckland. In the same year he obtained an appointment on the staff of the British Museum. In 1837 Mr. Charlesworth was appointed an Assistant to the Museum of the Zoological Society of London, in Leicester Square; he also succeeded Loudon as Editor of the "Magazine of Natural History," which he continued to conduct until 1840. At this time he contributed several papers, on the comparative age of Tertiary deposits; on *Voluta Lamberti*; on *Terebratula variabilis*; and on the teeth of *Carcharodon megalodon* from the Crag, etc.

In 1840 he left England to take charge of a young gentleman of fortune and travel with him through Central America. At this time he occupied himself in patenting an "elevator gun," which he believed to be indispensable for the naturalist and explorer abroad, and hoped to see adopted also for the British army. Twenty years later an enterprising American, Mr. Pomeroy Button, of Cheapside, obtained for it, by advertising extensively, an ephemeral success of a few months and a temporary accession of capital to its inventor; but it was of too brief duration to lead on to fortune.

On returning to England Edward Charlesworth was, in 1844, appointed successor to Prof. John Phillips, as Curator to the Yorkshire Philosophical Society's Museum in York, a post which he held until 1858. In 1846 he brought out the "London Geological Journal," which contained most valuable contributions from the leading palæontologists of the day, and occasionally strong and useful critiques on some of their published facts and opinions. This publication was profusely illustrated by plates; but unfortunately it only extended to three numbers and ceased in 1847.

In this MAGAZINE he contributed a valuable paper on the occurrence of flint in the pulp-cavity of a tooth of *Mosasaurus*.

On Mr. Charlesworth's retirement from York, in 1858, he settled for a time in London, and carried on a Natural History and Geological Agency; but his predilection for the Suffolk Crag caused him to spend much of his time in the Orford, Sutton, and Woodbridge districts in search of fossils. In this he was largely aided by his kind friends, Mr. William Colchester, F.G.S., then of Grundisburgh Hall, near Woodbridge, and Mr. Searles V. Wood, F.G.S., and his son Mr. Searles V. Wood, jun. Encouraged and supported by Mr. William Reed, of York, Edward Charlesworth was, for many years, one of the most active buyers of fossils in London; always seeking to secure the best specimens and paying the highest price for them. In fact, he devoted himself almost solely to the purchase of specimens for Mr. Reed and the British Museum; and the "Reed Room" in the York Museum, and the National Collection, both contain numerous evidences of his keen powers as a collector, especially of the fossils of the Crag District. He was the first naturalist to introduce glass-topped boxes into use in museums for the preservation of delicate specimens, and he set up a manufactory of round glass-topped boxes on a large scale. But it must be confessed that he did not succeed as a man of business, owing to the absence of training in early life. Some of his scientific papers are most excellent, and, as a speaker, he was possessed of great fluency and keen powers of argument. He seldom appeared at a scientific meeting in which he did not take part in the discussion, and, if possible, divert it to the Suffolk Crag, the formation of flint, or some other of his pet theories, about which he never grew tired of collecting evidence and challenging inquiry among his brother geologists.

One of his most recent papers was upon flints, and was communicated to the Victoria Institute.

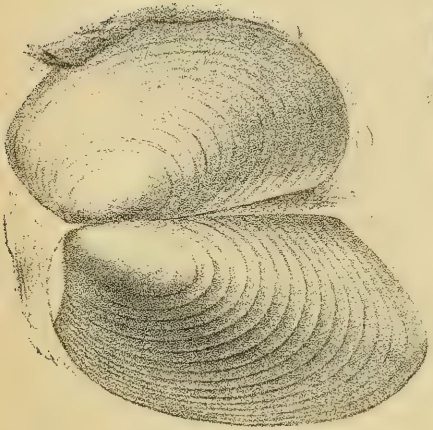
Mr. Charlesworth was greatly interested in the "Oaths Bill"—especially in reference to the swearing of children whose evidence had to be given in Courts of Justice—a practice he was instrumental in getting abolished. He also took an active part in the establishment of the "Society for the Prevention of Cruelty to Children." His sister, Miss M. L. Charlesworth, wrote the story of "Ministering Children," one of the most widely-circulated children's books ever written.

The Royal Society gives a list of 28 papers on scientific subjects, published by Edward Charlesworth; but he printed and circulated at his own expense an immense number of pamphlets on various social and other subjects, and as a correspondent he probably will never be surpassed for the abundance and length of his letters. Referring to his wonderful powers as a speaker, the Rev. William Vernon Harcourt (founder of the British Association) is reported to have said of him ("York Herald," February 7, 1857): "Mr. Charlesworth has shown us that he is not only intimately acquainted with extinct creatures, but that he has a knowledge of, and knows how to influence, the living creation."

He died at his residence at Saffron Walden, after a comparatively short illness, on the 28th July, at the age of eighty years.

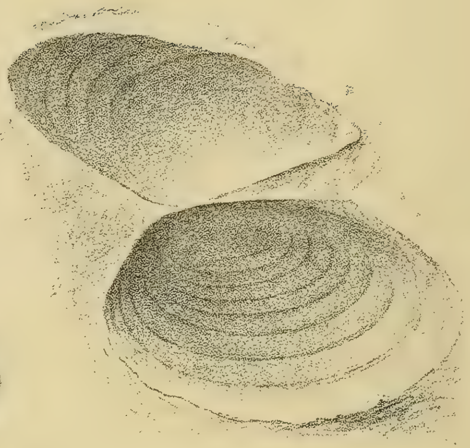
H. W.

1.



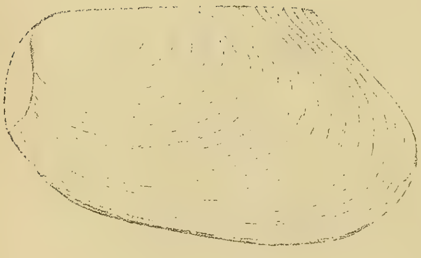
X 15.

3.



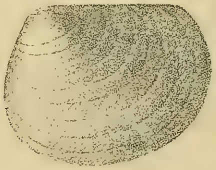
X 15.

2.



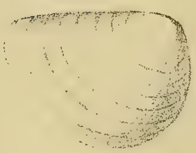
X 15.

4.



X 20.

5.



X 20.

PERMIAN ESTHERIÆ

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. X.

No. XII.—DECEMBER, 1893.

ORIGINAL ARTICLES.

I.—The Fossil Phyllopoda of the Palæozoic Rocks.[1]

By Professor T. Rupert Jones, F.R.S. and Dr. Hy. Woodward, F.R.S.

(PLATE XIX.)

Contents.

I. *Phyllocarida*, from North Wales.
II. *Estheriæ*, from the Wetterau, Germany.
    1. *Estheria striata* (Münster), var. *Muensteriana*, nov. figs. 1 and 2.
    2. *E. Reinachii*, sp. nov., fig. 3.
    3. *E. Geinitzii*, sp. nov., fig. 4.
    4. *E.* ——, var. *Grebeana*, nov., fig. 5.
III. *Estheriæ*, from Bohemia.
IV. *Phyllocarida*, from Iowa and Indiana.
V. *Anomalocaris*, from Canada.
VI. *Caryocaris Salteri*, from Australia.
VII. *Aptychopsis anatina* (Salter) and *Peltocaris Marrii*, sp. nov.
VIII. Geological Distribution of the Palæozoic Peltate Phyllopoda.

I. The *Phyllocarida*, from North Wales, referred to in the last Report (for 1892, p. 299) as having been lent by Mr. G. J. Williams, F.G.S., of Ffestiniog, have been duly examined, and several described and figured, together with some other specimens, in the Geological Magazine for May, 1893, pp. 198–203, Plate X., by T. R. Jones and H. Woodward. These comprise *Peltocaris Salteriana*, sp. nov. (Fig. 1), *Dipterocaris Etheridgei*, J. and W., 1884 (Fig. 3), *Aptychopsis Williamsii*, sp. nov. (Fig. 7), *Ceratiocaris insperata*, Salter, 1866 (Figs. 8 and 9); besides a fragment? (Fig. 6), an undetermined specimen (Cut, p. 203), a *Conularia* (Fig. 2), and two Mytiloid shells (Figs. 4 and 5).

The other specimens were: *Hymenocaris vermicauda*, Salter; four pieces from the Middle Lingula-flags at Borth, and (Middle?) in the cutting near Wern; and (not rare) from the Upper-Tremadoc beds at Garth Hill; all near Portmadoc. *Saccocaris major* (Salter); small individual from the Upper-Tremadoc at Tuhwnt i'r bwlch, Portmadoc. *Lingulocaris siliquiformis*, Jones; from the Upper-Tremadoc, at Garth Hill.

II. Several *Estheriæ*, from the Permian strata of Germany, submitted for examination by Baron Albert von Reinach, of Frankfort-on-the-Main, prove to be:—

1. Estheria striata (Münster), var. Muensteriana, nov. Pl. XIX. Figs. 1, 2.

Length, 3·66 mm.; hinge-line, 2·46 mm.; height, 2·0 mm.

Near to the var. *Beinertiana*, Jones (Monograph Fossil Estheriæ,

---

[1] Being the Tenth Report to the British Association, September, 1893.

Palæont. Soc. 1862, p. 25, pl. 1, figs. 11–14), but more angular and sloping posteriorly, and not nearly so truncate on that border as in var. *Binneyana*, Jones, *loc. cit.* fig. 9, nor rounded, as in var. *Tateana*, Jones, *loc. cit.* figs. 15 and 18.

Like the before-mentioned varietal forms of *Estheria striata*, this has a straighter back than shown in the figures given by Goldfuss and De Koninck, and a sharper postero-dorsal angle than seen in any of the published figures. We may mention that fig. 8, pl. 1, Monogr. Foss. Esther., is less oblong than the original figures referred to above, and is deeper (higher) posteriorly; fig. 9 is more truly oblong; figs. 11 and 13 are more oblique, sloping posteriorly; fig. 15 is oblique, but shorter than figs. 11 and 13; and fig. 18 is shorter and subquadrate.

The indications of interstitial ornament are feebly evident in some of those mentioned above, and we cannot find any in these now under examination.

Differing from the foregoing varieties it should be regarded, we think, as another variety, which we wish to specialize as *Estheria striata*, var. *Muensteriana*, thus naming it after Count Münster, who was one of the earliest observers of these Palæozoic Phyllopods and of other fossil bivalve Entomostraca.

In its postero-dorsal angle and long hinge-line this form much resembles the recent *Estheria Rubidgei*, Baird (Proceed. Zool. Soc. 1862, pl. 15, fig. 3).

Fig. 1 illustrates the two valves lying together on the matrix, and in Fig. 2 the left valve is seen without any perspective.

It is in bluish-grey Lebach Shale of the lower part of the Rothliegende (Permian), at Altenstadt in the Wetterau, Grand Duchy Hessen, where it was discovered by Herr von Reinach with other fossils, namely, *Xenacanthus Decheni*, Goldfuss; *Acanthodes*, sp.; *Branchiosaurus amblyostomus*, Credner (*Protriton petrolei*, Gaudry), and some of the leading plants of the Permian series.

In these Lower Lebach Shales from Altenstadt, Wetterau, A. von Reinach also found numerous small Ostracodes, which T. R. Jones and J. W. Kirkby have determined as:—

Leperditia Okeni (Münster), very common.
,, ,, var. *acuta*, J. and K. } less common.
,, ,, ,, *oblonga*, J. and K. }
,, ,, ,, *parallela*, J. and K., rare.
,, *Youngiana*, J. and K., rare.
Cythere superba? J. and K., common.
Bairdia? etc.

The series of formations yielding these Phyllopoda and Ostracoda have been especially studied of late years,[1] and belong to the Rothliegende of the Permian system of the Middle Rhine, Main, and Wetterau (equivalent to that of the Nahe and Saxony).

---

[1] See Ch. E. Weiss, *Fossile Flora der jüngsten Steinkohlenformation und des Rothliegenden im Saar-Rhein-Gebiete*, 1869–72, p. 6; Kayser's *Lehrbuch der geologischen Formationskunde*, 1891, p. 149; and A. von Reinach, '*Das Rothliegende in der Wetterau und sein Anschluss an das Saar-Nahegebiet*'; *Abhandl. Königl. Preuss. geol. Landesanstalt, neue Folge*, Heft 8, 1892, p. 3.

PART OF THE PERMIAN SYSTEM.

Upper Rothliegende		Kreuznach Beds. Wadern Beds.			
Lower Rothliegende	Upper Middle Lower	Lebach Beds.	or		Sötern Beds. Tholey Beds. Lebach Beds.
	Upper Lower	Cusel Beds.		Upper Lower	Cusel Beds.

CARBONIFEROUS SYSTEM.

Upper, Middle, and Lower Ottweiler Beds.
Upper, Middle, and Lower Saarbrück Beds.

Estheriæ are also known in the Lower-Lebach Beds at Baerweiler-on-the-Nahe.

2. ESTHERIA REINACHII, sp. nov. Pl. XIX. Fig. 3.

Length, 3·2 mm.; hinge-line, 1·73 mm.; height, 1·86 mm.

This suboval *Estheria*, represented by two united valves (concave and one imperfect), is shorter and proportionally higher than Fig. 2, and has a much shorter hinge-line, which is straight, and not quite equal in length to the height of the valve. The umbo is not so near to the antero-dorsal angle as it is in Figs. 1 and 2, and therefore the ridges or lines of growth are less obliquely concentric with the umbo; they are also wider apart.

This form is not so bluntly rounded at the ends as *E. tenella* (Monogr. Foss. Esther. p. 31, pl. 1, fig. 26; pl. 2, fig. 39; and pl. 5, figs. 1–7); and it is much too angular and sloping posteriorly to match Goldenberg's pl. 2, fig. 9. In this last-mentioned feature it shows an alliance with *Estheria striata*; but its shape and proportions decidedly separate it as a species, and we give it the name *E. Reinachii*, after Albert von Reinach, who discovered it in the light-grey shale of the Upper-Lebach Beds in the Engelthal, near Altenstadt, in the Wetterau.

3. ESTHERIA GEINITZII, sp. nov. Pl. XIX. Fig. 4.

Length, 1·4 mm.; hinge-line, 1·0 mm.; height, 1·05 mm.

This (left valve) is subquadrate, with the anterior and ventral more fully rounded than the posterior border. The back is straight, and the umbo is at its front end.

This somewhat approaches to the shorter and deep (high) forms of *Estheria minuta* (Monogr. Foss. Esther. pl. 2, figs. 1, 5), but is readily distinguishable. It is still nearer in shape to a form of *E. Mangaliensis*, *op. cit.* pl. 2, figs. 20, 23, but the latter has not the postero-dorsal angle sufficiently pronounced. *E. subquadrata* (GEOL. MAG. 1890, Pl. XII. Fig. 2) has some resemblance to the form shown by Fig. 4, but it is not truncate anteriorily, and its postero-dorsal angle is weak.

The steep slope of the front edge, the full ventral curve, the contracted posterior moiety, and the well-pronounced postero-dorsal angle distinguish this form from any yet published. We dedicate it to our old friend Hofrath Geinitz, of Dresden, who has always been deeply interested in fossil Entomostraca and in the strata from which those of the Wetterau have been obtained.

This short form, deep (high) in its anterior moiety, is abundant (gregarious) in a dark greenish-grey, nearly black, shale, ferruginous on one face, of the Lebach Beds, from the Boos Tunnel, on the Rhine-Nahe Railway, and on the same geological horizon as at Altenstadt.

4. ESTHERIA GEINITZII, var. GREBEANA, nov. Pl. XIX. Fig. 5.

Length, 1·2 mm.; hinge-line, 1·05 mm.; height, 0·9 mm.

Fig. 5 (right-valve) is subtriangular and differs from Fig. 4, owing to the great proportional length of the hinge-line and the less fully rounded free margins. The front border is truncate, sloping downwards and inwards; and the hinder margin slopes downwards at once and forwards, and not partly outwards as in Fig. 4.

These differences in outline do not seem to be due to bad preservation, for the ridges are truly concentric with the margins, as far as they are exposed; but they are varietal, if not sexual. Hence Fig. 5 may be distinguished as var. *Grebeana*, after Herr Grebe, of the Prussian Geological Service, who found it crowded together with *E. Geinitzii* in the hard, dark-coloured Lebach Shale from the railway tunnel near Boos, a village about one kilometre from Münster-on-the-Nahe.

III. In Katzer's Geologie von Böhmen, III. Abtheilung, 1892, the following fossil Phyllopoda are mentioned:—

P. 1169, *Estheria cyanea*, Fr., from Lubna ? (Lubno).
P. 1156 ,, *tenella* (Jordan), from Nürschan (Nỳřany), } Post-
P. 1156 ,, sp. from Třemošnà, } Carboniferous.

Since that date our friend Dr. Anton Fritsch has shown us some figures of Phyllopods which probably comprise those referred to above. These figures are: 1, *Estheria*, from the lowest horizon of the Permian system of Bohemia, in the bituminous shale of Nyràn, near Pilsen; 2, *E. cyanea*, sp. nov., Fritsch, from the Middle Permian, in bituminous shale from Kaunovà; 3, an *Estheria* from Upper Permian bituminous shale at Kàstialov; 4, an *Estheria* from the limestone with *Palæoniscus Vratislavensis* of the Uppermost Permian at Braunau; 5, an *Estheria*, also from the Uppermost Permian Limestone. These, with some Ostracodes, will be published in due course by Dr. A. Fritsch in his "Fauna der Gaskohle," some parts of which have been already issued.

IV. S. S. Gorby, State-Geologist has issued some "Advance Sheets from the Eighteenth Report of the Geological Survey of Indiana" (8vo. Indianapolis, September, 1892), in which the Palæontology is done by S. A. Miller and S. A. Casseday (see p. 23). Some *Phyllocaridæ* of the family of *Pinacaridæ* are treated of, and at p. 77, pl. ix. fig. 37, the post-abdomen (trifid) of *Mesothyra Gurleyi*, n. sp., from the Kinderhook group, at Le Grand, Iowa, is described and illustrated; and at p. 78, pl. ix. figs. 43–46, *Macrocaris Gorbyi*, n. gen. et sp. from the Keokuk group, at West Point, Indiana. Of this latter form, fig. 43 shows the interior of the carapace valves and four abdominal segments. Fig. 44 gives four and part of another abdominal segment, and the post-abdomen slightly broken at the end. Fig. 45 is eight abdominal segments and the post-abdomen. Fig. 46 is a tooth, found in the same rocks, that may possibly belong to the internal masticatory apparatus.

V. In the Canadian Record of Science, vol. v. No. 4, October, 1892, pp. 205–208, Mr. J. F. Whiteaves gives a "Description of a new Genus and Species of Phyllocarid Crustacea from the Middle Cambrian of Mount Stephen." The fossil is shown by a figure at page 206, and named *Anomalocaris Canadensis*, gen. et sp. nov. The diagram and description do not make it appear to us to be a Phyllocarid.

VI. Mr. Robert Etheridge, jun., in the Records of the Geological Survey of New South Wales, vol. iii. part 1, 1892, pp. 5–8, pl. iv. describes and figures four specimens of the *Hymenocaris Salteri*, M'Coy, and states his belief that they belong to *Lingulocaris*; and, as there is a *L. Salteriana*, he thinks that they should be called *L. Maccoyii*.

One or more specimens of this Australian species had been seen by Mr. J. W. Salter, and referred by him to *Caryocaris* with some doubt. We have adopted Mr. Salter's conclusion, both in a former Report (for 1883) and in the Monogr. Brit. Palæoz. Phyll., Pal. Soc. 1892, p. 93. Comparing Mr. Etheridge's figures with those of *Caryocaris* given by ourselves (*op. cit.* pl. xiv. figs. 11–15), we find that one of ours is as large as any of the former, and that the modified shape of the ends of the valves does not necessarily remove them from *Caryocaris*.

VII. With respect to *Aptychopsis cordiformis*, sp. nov., and *Peltocaris anatina*, Salter, mentioned at page 299 of the Report for 1892, Mr. J. E. Marr informs us that the words "Coll. Marr" should not have been attached to the former in our Monogr. Pal. Phyll. part 2, 1892, p. 103, pl. 15, fig. 2, for it was collected long ago, being the only Palæozoic shield-shaped Phyllopod in the Cambridge Museum when Salter labelled it *Peltocaris anatina*, overlooking its real generic character, and perhaps regarding it as a distorted specimen. By this name the specimen has been referred to in lists of fossils as from "Wenlock," and the real *Peltocaris*, which we have named *P. anatina* (Monogr. Pal. Phyll. p. 114, pl. 16. figs. 4–9) is a "Llandovery" fossil. It seems to be expedient to give the old name *anatina*, instead of *cordiformis*, to the *Aptychopsis* (p. 103), as intimated by Mr. Marr in the GEOLOGICAL MAGAZINE for December, 1892, p. 535; and to distinguish the *Peltocaris* (p. 114), some specimens of which were collected by Mr. Marr, as *P. Marrii*.

VIII. We here append a table showing the geological distribution of the several Peltate Phyllopods described and figured in our Monograph and referred to at page 298 of the Report for 1892.

Aptychopsis prima, Barrande
,, ,, var. *longa*, J. and W. } Étage E e 1, Bohemia.
,, ,, var. *secunda*, J. and W.
,, *Barrandeana*, J. and W. Birkhill group (upper part of the Moffat series).
,, ,, var. *brevior*, J. and W. Birkhill group?
,, *anatina* (Salter). Lower Wenlock, Ulverston.
,, *lata*, J. and W. Gala series.
,, *glabra*, H. Woodward. Gala series.
,, *Wilsoni*, H. Woodward. Riccarton series.
,, *Lapworthi*, H. Woodward { Gala series. Birkhill group. Skelgill Shales, Lake district.
,, *ovata*, J. and W. Gala series.
,, *Salteri*, H. Woodward. Wenlock Shale, South Wales.
,, *subquadrata*, J. and W. Upper Silurian, Ireland.
,, *angulata*, Baily { Upper Silurian, Ireland. Brathay Flags (?), Lake district. Birkhill group?
,, *oblata*, J. and W. { Riccarton series. Gala series. Birkhill group.
Peltocaris aptychoides, Salter { Gala series. Birkhill group.
,, *Marrii*, J. and W. { Birkhill group. Skelgill Shales.
,, *patula*, J. and W. { Birkhill group. Skelgill Shales.
,, *Carruthersii*, J. and W. Birkhill group.
Pinnocaris Lapworthi, Eth. { Upper Silurian, Kendal. Lower Silurian, Girvan.
Discinocaris Browniana, H. Woodward { Birkhill group. Skelgill Shales.
,, *ovalis*, J. and W. Birkhill group.
,, *undulata*, J. and W. Birkhill group.
,, *gigas*, H. Woodward { Birkhill group. Skelgill Shales.
,, *Dusliana*, Novák. Étage E e 1, Bohemia.

The general order of the strata is:—

4. Pentland or Riccarton Series. Brathay Flags. (Wenlock Beds.)
3. Gala Series.
2. Moffat Series. {
    3. Birkhill group. Skelgill Shales. (Llandovery Beds.)
    2. Hartfell group.
    1. Glenkiln group.
1. Arenig Series.

EXPLANATION OF PLATE XIX.

Permian Estheriæ.

Fig. 1. *Estheria striata*, var. *Muensteriana*, nov. } From Lebach Shale, lower part of the Rotheliegende (Permian), at Altenstadt, in the Wetterau, Grand Duchy Hessen, discovered by Herr von Reinach.
,, 2. ,, ,, ,, ,,
,, 3. ,, *Reinachii*, sp. nov. Upper Lebach beds, Engelthal, near Altenstadt, Wetterau.
,, 4. ,, *Geinitzii*, sp. nov. Lebach beds, Boos Tunnel, Rhine-Nahe Railway.
,, 5. ,, ,, var. *Grebeana*, nov. Lebach beds, Boos Tunnel, near Münster-on-the-Nahe.

These specimens are preserved in the Geological Department of the British Museum (Natural History), Cromwell Road, S.W., having been presented, through the authors, by the Baron Albert von Reinach.

Geological Magazine for May, 1893, page 202, line 14 from bottom, *for* Fig. 10 *read* Fig. 9.

II.—ON THE CONVERSION OF CHLORITE INTO BIOTITE IN ROCK-METAMORPHISM.

By CHARLES CALLAWAY, D.Sc., M.A., F.G.S.

IN a paper[1] read before the Geological Society of London, in 1889, I contended that the biotite of the gneisses and schists of Malvern had been produced out of hornblende through the intermediate form of chlorite. As this mineral change is of capital importance in explaining the origin of the Malvern schists, I made it one of the principal topics of the paper, and I trusted that the evidence I offered in support of it would be considered adequate. The further communication on the Malvern rocks, which I read on April 26th of the present year, assumed the adequacy of this proof. I found, however, that in certain quarters some scepticism on the point still existed, and it was suggested that I had overlooked some of the chemical difficulties which seemed to forbid the acceptance of my view. I therefore crave permission to reply to this objection in these pages; and I desire, at the same time, to point out that since the reading of my paper in 1889, the production of biotite from chlorite has been affirmed by several writers of admitted authority.

Professor Lossen, in the paper[2] on the crystalline schists communicated by him to the International Geological Congress, which met in London in 1888,[3] distinctly takes my view. He states that biotite is produced in "diabase" as the result of contact with granite and other eruptive masses, and he adds that this biotite is visibly formed at the expense of chlorite originating in "augite or primary hornblende."

M. Michel Lévy, on the same occasion, communicated a paper[4] on an allied subject. He is describing the metamorphism of detrital rocks. In the first stage, the cement of the fragments forming (say) a sandstone is converted into chlorite and sericite. In a more advanced stage, "sericite and the chlorite give place to interlaced laminæ of black mica."

A third writer, Prof. Salomon,[5] describes a case somewhat similar to the last, but the conditions are simpler. A phyllite is in contact with an eruptive mass of diorite, and the chief change produced in the phyllite is the conversion of chlorite into biotite.

This mineral transformation has also been described by Rüdermann.[6]

I have not given the precise details of the causes of change in each of these cases, because my object is merely to record confirmations of a statement. If I am wrong in affirming that chlorite may be converted into biotite, it is very singular that several foreign observers of undoubted competence should have independently arrived at the same conclusion.

---

[1] On the Production of Secondary Minerals at Shear-zones in the Crystalline Rocks of the Malvern Hills, Q.J.G.S., August, 1889, p. 475.

[2] Einige fragen zür Lösung des Problems der Krystallinischen Shiefer, nebst beiträgen zu deren beautwortung aus dem Paläozoicum; Compte Rendu, p. 180.

[3] This date is of course prior to 1889, but Prof. Lossen's paper was not known to me till after mine had been sent in.

[4] Sur l'Origine des Terrains Cristallins Primitifs; Compte Rendu, p. 58.

[5] Zeits. d. deutsch. geol. Ges. 1890, xlii. p. 450.

[6] Neues Jahrb. v. Beilage-Band (1887), p. 643.

If this mineral transformation is an observed fact, it may seem unnecessary to discuss theoretical objections to it; yet, since competent observers have so recently called it in question on the ground of these objections, it would be inexpedient to pass them over. Is there any theoretical reason why, under the conditions existing in the Malvern rocks, biotite should not be generated at the expense of chlorite? I venture to think there is none, and this I will endeavour to show.

It is rarely possible to determine the species of chlorite in the Malvern rocks, as the mineral usually occurs in irregular patches and strings. It is identified by its habit, its colour, its pleochroism, and its very low interference tints. The biotite is easily recognised, and does not require to be described in this place. For our present purpose, it will be sufficient to compare the average composition of the two minerals. The following percentages cannot be very far from the truth.

	Chlorite.	Biotite.
Silica	33	40
Alumina	16	18
Iron peroxide and protoxide	5	16
Magnesia	34	18
Potash	—	8
Water	12	—
	100	100

In the change from chlorite to biotite, we have to account for a gain of silica, iron oxide, and potash; and for a loss of magnesia and water.

The liberation of *silica* is one of the most obvious features of the first stage of metamorphism, viz. decomposition. The crushed diorite, which is to become a mica-gneiss, is quite dirty with disseminated iron oxide, and is often freely veined with calcite. The elimination of lime and iron oxide would, of course, set free plenty of silica.

The last paragraph tells us where the *iron oxides* come from. That they are in part used up in the generation of biotite can almost be demonstrated under the microscope. In some slides, grains of opaque matter lie in the midst of blotches of chlorite, and round each of these grains is a halo of biotite, which can be identified by its brown colour, its strong pleochroism, and its high interference tints. In other slides, the chlorite is traversed by cracks filled in with opaque brown granular matter, and each of these cracks is fringed on each side by biotite. This opaque matter must be some form of iron oxide, it is not material which, and one seems driven to conclude that the pleochroic halos are causally connected with the union of the constituents of chlorite with the iron oxide.

It is evident that we cannot trace *potash* under the microscope. Some of this alkali is furnished by the decomposition of the felspar of the diorite. An analysis of the medium-black diorite (my No. 1), made by Mr. Player, gives a percentage of 2·8 of potash. Another percentage by the same analyst is 3·9. In this case the diorite is the same variety as the first, but it has been slightly modified, and contains a little biotite. An analysis by Mr. Player of the coarse-grey diorite[1] (No. 3) yields 4·3 of potash; but this percentage is probably exceptionally high, as another of his analyses of the same rock, slightly crushed and decomposed, gives only 2·5 per cent. of potash. The schist formed out of this diorite contains 3·7 per cent. of this alkali, but in a schistose rock which is just graduating into this schist the percentage of potash is as low as 1·9. It appears then that at Malvern diorite itself supplies a certain amount of potash for the construction of biotite.

Another source of potash is the adjacent granite.[2] The effect of the infiltration of potash is seen in the production of biotite in diorite in the proximity of the veins. Analyses were made by Mr. Player of rocks in the section[3] at the southern end of Swinyard's Hill. At a few yards from the veined complex the diorite (No. 1) contains only 2·8 per cent. of potash. In contact with the complex of veins, the diorite is changed into biotite-gneiss, where the proportion of potash has risen to 5·3 per cent. There seems then to be little difficulty in accounting for the potash necessary for the conversion of chlorite into biotite.

We have next to consider the loss of magnesia and water. The reduction of the percentage of *magnesia* in the transformation of diorite into sericite-gneiss or into biotite-gneiss is demonstrated by analysis. Four analyses (Mr. Player's) illustrate the change from diorite to sericite-gneiss. The magnesia percentages are respectively 5·0, 5·3, 4·1, 2·6. The first (5·0) is from the uncrushed diorite; the second (5·3) is from the diorite crushed and decomposed; the third (4·1) is the rock crushed into a micaceo-chloritic grit; the fourth (2·6) is the sericite-gneiss. Two analyses of the same schist made at Owens College under the direction of Dr. Cohen give respectively 1·29 and 0·35 of magnesia. Analyses made by Mr. Player of rocks from the Swinyard's Hill section illustrate the change into biotite-gneiss. They give 7·3 of magnesia in the ordinary diorite, and 1·9 in the resulting biotite-gneiss. Another specimen of the latter yields to an analysis by Mr. Waller 2·8 of magnesia, and this rock passes into varieties in which two analyses give respectively 1·9 and 1·4 of magnesia. The elimination of magnesia is therefore clearly shown.

Water was not separately estimated in the analyses made for me. Its elimination would seem, however, to offer no serious difficulty.

---

[1] This rock contains too much potash for a normal diorite. As a large proportion of the felspar is plagioclase, and the silica percentage is only 47, it can hardly be a syenite.

[2] Discussed in Quart. Journ. Geol. Soc. (1889), pp. 482–487, 499.

[3] *Ibid.* p. 482.

Chlorite loses water even at a red heat, a clear proof that the affinity between the water and the other constituents of the mineral is not very strong. The temperature of metamorphism in the Malvern rocks often rose to the point of fusion in the shear-zones, and, if in other respects the environment of the chlorite were such as tended to change it into biotite, there would seem to be no theoretical objection to the expulsion of the combined water.

The decomposition of biotite (or hornblende) into chlorite is of course a very familiar fact, and, if the two minerals are found in the same rock with an apparent passage between them, it is natural that those who have not studied the evidence furnished by the Malvern rocks should adopt an old and well known explanation of the phenomena in preference to a new and seemingly improbable one. It seems easier to believe in a decomposition than in a reconstruction. We must, however, follow whither the facts lead us. The reason why in the Malvern rocks we have sometimes a decomposition of hornblende into chlorite, and sometimes a change of chlorite into biotite, is found in the difference of environment. Where the rock is slightly crushed, and there are no signs of rock-fusion, there is decomposition of hornblende; but where there is intense crushing and shearing, accompanied by a high temperature, reconstruction sets in and biotite is generated.

In the three papers which I have submitted to the Geological Society on Rock-metamorphism at Malvern, I have embodied the results of several years of careful work. If any parts of my argument are weak or mistaken, I respectfully ask that the defects may be pointed out.

III.—NOTES ON THE EOCENE TERTIARY INSECTS OF THE ISLE OF WIGHT.

By the Rev. P. B. BRODIE, M.A., F.G.S.

THERE are some points of special interest with reference to the Insect remains from the Bembridge Limestone, near Cowes, which seem to be worth recording. My friend Mr. Scudder, who has done so much to promote the study and elucidate the history of fossil insects, and who is our highest authority upon the subject, remarks in one of his papers in the United States Bulletin, that in no case had he observed the interior of any insect in a fossil state, and that the internal structure could hardly be expected to be detected. As a rule, no doubt, this is perfectly correct, and I have never noticed any insect relic either in the Purbecks or Lias which showed any portion of the interior, and I am not aware that any foreign fossils of a similar class where they occur have done so. But the Articulata of the Isle of Wight Tertiaries are certainly a remarkable exception. I have lately carefully examined a large number of specimens in my collection with a powerful lens, and in the majority of cases the insects, mostly of small size, have the interior of their bodies exposed, among which, as in other Tertiary deposits, ants, which chiefly belong to the Formicidæ, predominate;

but only one example of an Hymenopterous insect, an ant, is known earlier—from the Swiss Lias recorded by Heer. The insects in the Bembridge Limestone, as a rule, are lying on their backs, the interior of the body being exposed, and showing even the internal structure, in other words, the anatomy of the animal, and in one instance, even what appears to be the ovipositor, and in another the intestine, may be detected. It often happens that only a mould of the interior of the entire body of an insect is left, the soft parts having been entirely decomposed. The matrix is a more or less hard and somewhat peculiar limestone, with a very perverse and uneven fracture, and may have been deposited in a small lake under unusual conditions. The limestone is not laid down in regular laminæ, as in many other Tertiary, and not unfrequently in earlier formations, which in some respects is a better condition for the display of the *Insecta;* but at Gurnet Bay they lie often crowded together, and in all directions in the matrix, which is often angular and irregular in structure. Hence the remains are most difficult to work out and expose, though the minute parts are wonderfully preserved. Mr. A'Court Smith informs me that he has found several butterflies, generally ill-preserved, though I have one fine example retaining both wings and showing traces of colouring; but the body is much decomposed. I have also a Gryllus, apparently with attached wings, and a small Blatta. There are also numerous spiders, caterpillars, centipedes, and worms.

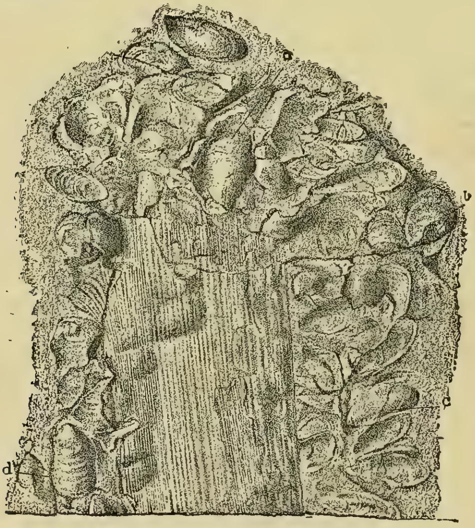
In some respects the Bembridge Limestone is, lithologically, not unlike the Rhætic at Aust Cliff, containing some well preserved insects, though only at one particular spot. Most of these Tertiary Arthropods must have undergone a considerable amount of decomposition and have been embedded with the lower portion of the body upwards, the very reverse of the ordinary preservation of most fossils of this class elsewhere. They appear to be confined to a very limited area, and so far are of local occurrence, for Mr. Starkie Gardner has stated that though he had carefully searched the equivalent beds in other parts of the island he had never met with them. This differs from the widespread range of Tertiary deposits in other parts of the world where, as in Colorado especially, there are several thin layers of fine-grained limestone which may be traced for many miles, more or less crowded with insect-remains in good preservation. The majority of these *reliquiæ* in the Isle of Wight are generally broken, crushed, and distorted, and the wings are not often attached; very different to those from Aix and other foreign Tertiaries. But the legs, antennæ, and eyes, are not unfrequently preserved, and in some cases the beautiful iridescent colouring of the body and wings are occasionally retained. This is rarely so in more ancient deposits, though the wings of *Brodiea* in the Coal-measures near Dudley retain their colouring and in other examples in the same deposits at Commentry, in France, and also in America.

Insect remains have only been recognized of late years in the British Tertiaries (though long known abroad) in any considerable number; and those only a few elytra of beetles; but now, through the intelligence and zeal of Mr. A'Court Smith in searching the rocks at Gurnet Bay, near Cowes, we owe the discovery of a large and varied series of Insects. My collection of Tertiary insects, numbering nearly two thousand specimens, is still unnamed and undescribed; and a few only of those in the British Museum, Natural History, are named and figured. It is much to be regretted that there is no English Entomologist who will undertake this work, and if Mr. Scudder was nearer, there is no one more competent to do this. Is there no one in this country who will take up the subject? No doubt those who have collections from the British Tertiaries, would willingly lend them for this purpose. I may add, that associated with these insects are several small feathers of birds, one of which is entire, the rest fragmentary. These are great rarities in British Tertiaries.

IV.—DESCRIPTION OF A SLAB FROM THE SHALE ABOVE THE KINDER SCOUT GRIT, RABCHESTER, LANCASHIRE. Obtained by R. H. TIDDEMAN, Esq., M.A., F.G.S.

By WHEELTON HIND, M.D., B.Sc. (Lond.), F.G.S.

MENTION is made of this slab by Mr. R. Etheridge, jun., in his Presidential Address to the Royal Physical Society of Edinburgh, p. 50. The specimen is in the Museum of Natural History, Cromwell Road, South Kensington.



Piece of fossil wood, from the Shale above the Kinder Scout Grit, Lower Carboniferous, Rabchester, Lancashire, surrounded by closely-packed shells of *Anthracoptera*, which were doubtless attached to the wood by their byssi.

The slab shows a piece of fossil wood $2\frac{3}{4}$ in. long by about $1\frac{1}{2}$ in. broad, the exact nature of which is not determinable on account of its bad state of preservation, but this is fortunately not germane to the subject; it lies flat and compressed and is surrounded on three sides by masses of Mollusca, in places two and three deep, which have doubtless been attached to the wood by their byssi. The anterior ends and in many cases the inferior borders are turned towards the piece of wood and are in close contact with it, while others are again attached to the first row, as in masses of living mussels.

The shells are much crushed; but in several places the distinctive characters of the genus *Anthracoptera* can be made out:—

(*a*) Is one showing the straight hinge-line, the triangular form, and oblique swelling.

(*b*) Is a specimen showing a typical posterior end.

(*c*) Shows a fairly well-preserved anterior end.

(*d*) Is a less crushed specimen than most.

Microscopically the shell-structure is identical with that of *Anthracoptera*.

This is the only specimen known which exhibits these shells attached by the byssus; but I have seen several slabs of small Posidonias similarly attached to calamite stems in the collection of Mr. George Wild, of Bardsley, from the Lower Coal-measures around Oldham.

V.—The Amount of Disseminated Silica in Chalk Considered in Relation to Flints.

By A. J. Jukes-Browne, B.A., F.G.S.

It has been supposed, though I do not know who was the first to suggest it,[1] that the total amounts of silica existing in the Chalk with flints and the Chalk without flints respectively are very nearly equal: the idea being that if the quantity of silica disseminated through the flintless Chalk could be accurately estimated it would be found to be nearly or quite as great as the amount existing in the shape of flints in an equal thickness of flinty Chalk.

Proceeding on this assumption it seems also to have been inferred that silica was originally disseminated through the mass of the Upper Chalk, and that this silica has in some mysterious way been concentrated into nodules and layers of flint, leaving the surrounding Chalk in the condition of a nearly pure calcareous material. If this supposition were true it could doubtless be used as an argument in favour of the theory that flints have been formed by some process of "segregation" after the consolidation of the Chalk. I believe, however, that it is a pure assumption, made without any due examination of the facts, but, as it has never been disproved, I shall probably be doing a service to those interested in the knotty question of the formation of flints by arraying the evidence against it.

In the first place, I presume it will be granted that the silica which went to make the flints was a soluble form of silica such as that of Sponge spicules, Diatoms or Radiolaria. The insoluble silica which is present in the shape of quartz-sand and clay must therefore be left out of consideration, and consequently no analysis of Chalk which does not separate the soluble from the insoluble silica will be of any use.

---

[1] The late David Forbes, F.R.S., in Proc. Geol. Soc.—Edit. Geol. Mag.

Here arises the question of what is "soluble silica?" In commercial analyses of soils and rocks the silica recorded as "soluble" is only the small amount which is soluble in warm hydrochloric acid; but, properly speaking, soluble silica is that which can be dissolved in an alkaline solution of a certain strength. Crystalline silica, such as quartz and chalcedony, are not soluble in such a solution, but all forms of non-crystalline or colloid silica are. We can therefore only use analyses which have been made by capable scientific chemists, and unfortunately there are not so many such analyses as geologists could desire.

The microscope, however, here comes to our assistance, for, by using the polariscope, we can easily see whether the siliceous particles are crystalline or colloid; checking the results by such good analyses as exist, we can determine whether flintless Chalk always contains soluble silica, and whether Chalk with flints contains little or none.

It will be convenient to consider the case of the Lower, Middle and Upper Chalk separately, for it is now known that flints occur in each of these divisions in more than one part of England.

1. *Lower Chalk.*—It used to be supposed that no flints were to be found in this division, but genuine flints, often with black centres, are common in the lowest part of the Chalk of Dorset; Mr. W. Hill, F.G.S., informs me that they also occur in that of Yorkshire. Siliceous concretions of the nature of flints also occur in the central part of the Lower Chalk of Wilts between Westbury and Urchfont.[1]

Mr. W. Hill has cut and examined samples of the Dorset Lower Chalk with flints, and finds that it differs from ordinary Chalk-marl, containing much less quartz and glauconite. There are few spicules, and no globular silica has yet been detected in any of the samples Mr. Hill has examined. The amount of quartz and glauconite is sometimes very small, and one sample of flint-bearing Lower Chalk was almost purely calcareous, with only one or two spicules visible in the slide. It might, therefore, be supposed that the Dorset flints occurred in Chalk which had been depleted of soluble silica.

The Wiltshire nodules, however, occur under just the opposite conditions, the surrounding Chalk being rich in colloid silica. Analyses by Mr. J. Brierly, of Southampton, gave over 12 per cent. of such silica, and the microscope shows that it exists partly in the form of sponge spicules, and partly in that of minute discoid and globular particles like those described by Dr. Hinde in the Malmstone of Surrey and Hants. Samples taken from just outside the cherty nodules showed no difference, except that the globules were rather larger than those in the mass of the deposit. The nodules themselves are simply portions of this siliceous Chalk saturated and cemented by an infiltration of chalcedonic silica.[2]

---

[1] Quart. Journ. Geol. Soc. vol. xlv. p. 405.

[2] Quart. Journ. Geol. Soc. vol. xlv. p. 415.

Are we to suppose that we have here a case of the arrested development of flint? Possibly, but it would be very rash to assume that the Dorset Lower Chalk was originally a siliceous Chalk similar to that of Wiltshire. Nor is the latter the most siliceous Chalk known, for some beds at Collingbourn Kingston, near Andover, in Hants, contain over 38 per cent. of such silica. The following analysis of Collingbourn Chalk I owe to the kindness of Professor J. B. Harrison, of Demerara, who adopts a special method for separating the free colloid silica from that existing in combination with bases such as Alumina and Iron.[1] The analysis is consequently of special value and accuracy:—

ANALYSIS OF SILICEOUS CHALK, COLLINGBOURN.

Organic matter, etc.	1·69
Quartz	13·41
Colloid silica	38·69
Silicates (Clay, etc.)	14·75
Calcium sulphate	0·49
Calcium carbonate	30·77
Calcium phosphate	trace
	99·80

Here then is a Chalk which actually contains more colloid silica than carbonate of lime; if flints were formed by the subsequent solution and concentration of such silica, how is it that the Collingbourn Chalk is not now a pure Chalk with frequent bands of flints? Evidently the formation of flints is not a matter of simple subsequent concentration, neither does it depend simply upon the abundance of disseminated colloid silica.

2. *The Middle Chalk* is that which lies between the horizons known as the Melbourn Rock and the Chalk Rock. It is, so far as we know, a very pure Chalk. The few analyses that have been made show that it contains from 97 to 98 per cent. of carbonates, and that it is therefore as purely calcareous as many parts of the Upper Chalk.

The distribution of flints in the Middle Chalk is somewhat remarkable: they appear to be absent in the Isle of Wight and in North Dorset; they occur sparingly in the central zone in Wiltshire, and increase in abundance northward till in North Cambs and Suffolk they form frequent layers of nodules. The character of the Chalk composing the zone of *Terebratulina gracilis* varies, however, very little; it consists largely of single calcareous cells with a few Foraminifera embedded in a matrix of very finely-divided calcareous ooze. Sponge spicules are rare, and no globular silica has been observed. This description applies equally to the flintless Chalk of the south and west, and to the portion containing flints in the counties of Hertford and Cambridge. The following is an analysis of Middle Chalk with flints from 60 feet above the Melbourn Rock at Hitchin; it has been kindly made for me by Prof. Harrison with the express purpose of ascertaining the amount of colloid silica.

---

[1] Quart. Journ. Geol. Soc. vol. xlv. p. 414.

ANALYSIS OF MIDDLE CHALK, HITCHIN.

Organic matter	0·10
Quartz	0·15
Colloid silica	0·35
Silicates (Clay)	1·68
Calcium sulphate	0·29
Calcium carbonate	96·15
Magnesium carbonate	1·34
	100·06

This closely agrees with Mr. Hume's analysis of Chalk from the zone of *Terebratulina gracilis* (Isle of Wight), which contained 97·76 per cent. of carbonates, and he says "the main residue consisted of a light-brown clay, entirely free from siliceous particles."[1] He found a few Foraminifera, but no sponge spicules nor any indication in the shape of glauconite rods that spicules had ever been present. This Chalk has no flints, while that at Hitchin has a few.

3. *Upper Chalk.*—In this division, as developed in the South of England, the Micraster zones are characterized by the extreme abundance of flints, the Marsupite zone by their rarity or absence, and the zones of *Belemnitella quadrata* and *B. mucronata* by a moderate number.

The Chalk of all these zones is very pure and similar in minute structure, except that shell fragments are sometimes very numerous in the Micraster zones.

Mr. Hume's researches show that the carbonates usually amount to between 98 and 99 per cent., only two samples yielding less than 98. He found no sponge spicules nor any kind of colloid silica in any of the samples he examined, but glauconite rods, which seemed to be the casts of spicular canals, were numerous in the residue of the *coranguinum* Chalk. There are, however, beds in the zone of *M. cortestudinarium* in the South of England which are crowded with spicules in which the silica has been replaced by calcite.

Prof. J. B. Harrison has specially examined two samples of Upper Chalk for colloid silica and sends me the following results: (A) being from Chalk with many flints near base of *coranguinum* zone north of Salisbury, and (B) from the Marsupite zone, with few flints, Bishops Down, Salisbury.

Dried at 100° C.	A	B
Moisture	0·30	0·20
Quartz	0·32	0·50
Clay	1·18	0·45
Colloid silica	0·50	—
Carbonates by difference	97·70	98·85
	100·00	100·00

It will be noticed that while the Chalk with many flints (A), has an appreciable amount of colloid silica, that with few flints (B), has none at all. This is not the result that might be expected if the two Chalks had originally equal amounts of disseminated silica.

---

[1] Chemical and Mineralogical Researches on the Upper Cretaceous zones of the South of England, London, 1893, p. 51.

Mr. Hume's analyses also prove the Marsupite Chalk of Margate and of Studland Bay (Dorset) to be purer than the Chalk of the underlying *coranguinum* at the same localities. From four analyses from each zone given by Mr. Hume (*op. cit.* p. 74) it would appear that the amount of insoluble residue in the *coranguinum* zone averages 1·78 per cent., while that in the Marsupite zone only averages 1·02 per cent.

Conclusions.—The facts and analyses above given are, I think, sufficient to prove that there is no definite relation between the occurrence of flints and the absence or presence of soluble silica in the surrounding Chalk.

The great abundance of siliceous spicules in certain parts of the Lower Chalk and their rarity in the Upper Chalk, cannot be taken as evidence of the greater abundance of siliceous sponges in the former; as a matter of fact, remains of sponges other than free spicules are far more abundant in the Upper. Neither can the absence of disseminated spicules in the Upper Chalk be accounted for on the supposition that they were once there but have been removed in solution *after the consolidation of the Chalk,* for why should they remain in the Lower Chalk, which has been upraised, inclined and exposed to the same action of percolating water as the higher part of the formation? Moreover, if the spicules or other siliceous organisms had existed in the Upper Chalk and had been subsequently dissolved, we should find traces of them either as empty tubes or as calcite casts. As a matter of fact there are beds both in the Lower and in the Upper Chalk where spicules occur abundantly in the state of calcite casts, but flints do not occur in them, nor are they specially abundant below them.

Hence the conclusion I have arrived at, from consideration of all the facts known to me, is that Chalk which is now destitute of any remains of spicules has, since it became Chalk, always been destitute of such spicules. It is possible that spicules may have lain for a time in the ooze which became Chalk; but if so I believe they were eventually dissolved in the sea-water before that ooze was raised or compacted into anything like Chalk.

How then, it may be asked, has it come to pass that spicules in the Lower Chalk have so often been preserved? That is a question not easy to answer; I have been tempted to suppose that the depth of the water had much to do with it, for there is good reason to think that the Lower Chalk was formed at depths of from 300 to 500 fathoms; while the characters of the Upper Chalk certainly indicate a much greater depth of water. The material of the Upper Chalk was probably deposited much more slowly than that of the Lower Chalk, so that the spicules of decaying sponges might have been dissolved before embedment.

The formation of flints, however, has certainly nothing to do with depth of water, because they occur in all parts of the Chalk and in the chalky limestone of the Portland series; and yet there may be some connection between the solution of spicules, diatoms, etc., and the formation of flints. It has always seemed to me that one of the conditions which led to the solution of spicules and the formation of flints was the presence of decaying organic matter; conversely it is not unlikely that the preservation of spicules is due to the absence of decaying organic matter at the time of their embedment.

It is known that some kinds of siliceous sponges periodically shed their spicules, and such shed spicules might be transported some distance by currents. The spicules in the Lower Chalk of Wilts seem to have been distributed in this manner, for remains of sponge-mesh are rare in that Chalk. We may assume, therefore, that when this Chalk was accumulated the amount of decaying protoplasm was very small, and consequently the spicules were not dissolved. In the Upper Chalk, on the other hand, and especially in the *Micraster* zones, there were evidently extensive sponge-fields, and yet spicules are seldom found except in the interior of flints which are silicified sponges. Does not this suggest the inference that the decay of the sponges set up reactions which caused first the solution of the scattered spicules and ultimately the precipitation of the silica in the form of flint?

VI.—Berthelot's Principle applied to Magmatic Concentration.[1]

By Alfred Harker, M.A., F.G.S.

It is now a recognized fact that many igneous intrusions, especially of basic rocks, grow more basic in composition from the centre to the margin. This type, of what Vogt terms "magmatic concentration," has been discussed by several geologists, who agree in supposing that in such cases a magma, originally homogeneous, has become differentiated by the migration of the less soluble (more basic) ingredients to the cooler marginal region of the magma-reservoir.

Taking the same ground, I wish to say a few words as to the physical cause of such migration. The explanation which has been offered, and may be regarded as the current one, invokes what has been named "Soret's principle," and is based on the generally admitted analogy between an igneous rock-magma and an ordinary saline solution. Soret[2] found by experiment that when different parts of a solution, originally homogeneous, were maintained for several weeks at different temperatures, the salt in solution tended to accumulate in the cooler part of the liquid. Van t'Hoff,[3] in his memoir on "osmotic pressure," arrived theoretically at the same result, and showed that for equilibrium the concentration of the salt in different parts of the solution must be inversely proportioned to the absolute temperature. Those results of Soret which gave the highest degree of concentration agreed with this law, and it seems probable that in his other experiments sufficient time was not allowed for complete equilibrium to be effected.

The principle just noticed seems at first sight to lead to an explanation of the concentration of iron-oxides, etc., in the cooler marginal part of an igneous rock-magma, but closer examination shows that the explanation is an inadequate one. To take a single instance: in a large intrusion of gabbro investigated by Mr. Marr and myself, the amount of magnetite was found to rise from less than one per cent. in the centre of the mass to 25 per cent. at the margin. It is clearly inconceivable that the absolute temperature at the centre was ever twenty-five times that of the margin. Other equally strong examples might be cited. Soret's principle is therefore insufficient, and it is not difficult to suggest a reason for its failure. The principle presupposes a dilute solution: if we imagine the solution to be near the point of saturation, and crystallization to take place in the parts actually saturated concurrently with the concentration, we have to deal with an essentially different set of conditions. We must then fall back on the general law of the degradation of energy, as formulated, for instance, in Berthelot's principle.[1] "Every chemical change accomplished without the intervention of any external energy tends to the production of that substance or set of substances which disengages the most heat." Or we may conveniently adopt Becker's extension of the law,[2] formulated thus: "The transformations will be such as to evolve heat, light, etc., at the highest possible rate."

---

[1] A paper read before the Brit. Assoc., Section C, at the Nottingham meeting.

[2] Annales de Chimie (5), vol. xxii. pp. 293–297 (1881).

[3] Zeits. f. phys. Chemie, vol. i. (1887).

Now the "heat of solution" of a salt in water is in some cases positive, in others negative; but we may fairly assume that the crystallization of a mineral from an igneous rock-magma is in general attended by the evolution of a considerable amount of heat, perhaps something of the same order as the latent heat of fusion of the mineral by itself. Hence, in a magma near the point of saturation, whatever promotes crystallization will promote the most rapid evolution of heat. In an unequally heated magma this must be effected by the accumulation of the least soluble ingredients in the part most easily saturated; that is, the concentration of the iron-oxide, etc., in the coolest region, and their crystallization there. It seems probable that the only practical limit to this action will be fixed by the growing viscosity of the magma, which, as follows from Vogt's[3] results, will be increased by the abstraction of the iron-oxides and other basic ingredients.

According to the view here offered, the Soret action, operating during the earlier stages, would bring about only a small part of the differentiation finally established. In consequence of it, and of the lower temperature of the reservoir towards the margin, the marginal portion of the magma would, as the whole cooled, be the first to become saturated, say with iron-oxides. At this point the further action to which I have drawn attention would come into play, and might produce much greater concentration of the iron in the outer part of the intrusion.

---

[1] Mécanique Chimique, vol. i. p. xxix.

[2] Amer. Journ. Science (3), vol. xxxi. p 191.

[3] Zeits. f. prakt. Geol. vol. i. p. 275 (1893).

NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE THE BRITISH ASSOCIATION, NOTTINGHAM, SEPTEMBER, 1893.

I.—ON THE BASE OF THE CAMBRIAN IN WALES. By H. HICKS, M.D., F.R.S., F.G.S.

IF there be, as has been maintained by the author and others, a very marked unconformity at the base of the rocks usually classed as Cambrian in Wales, the evidence furnished by an examination of those basal beds which indicate shore conditions is of the utmost importance. The author, therefore, in this paper gives a summary of the results bearing on this question which he has obtained in his examinations of these rocks in Wales.

PEMBROKESHIRE.

St. Davids.—The basal beds are exposed on the north and south sides of the pre-Cambrian Axis. Where faults do not intervene the lowest beds are rough conglomerates from 60 to 150 feet in thickness, in which pebbles over a foot in diameter are very frequently met with. The matrix and pebbles vary constantly, as they rest on different parts of the pre-Cambrian Axis, and there is the clearest evidence of an unconformity between the conglomerates and the highest beds of the Pebidian in this area. The overlying beds, which are grits and sandstones, are ripple-marked and show other proofs of having been deposited in shallow shore-water. The author has recently re-examined the basal beds in this area, and has accumulated additional evidence in support of the above view.

Ramsey Island.—The Cambrian conglomerates here rest on pre-Cambrian felstones and breccias. The pebbles are mainly well-rolled fragments of felstones cemented together by a felsitic matrix. Pebbles of quartzite and other materials are occasionally found, but the main amount of the material was undoubtedly derived from the rocks immediately underlying the conglomerates. The underlying rocks had undergone the marked changes now visible in them before the fragments in the conglomerates had been broken off.

Trefgarn.—The pre-Cambrian rocks in this area are mainly felstones of a peculiar type and volcanic ash. The conglomerates which repose on these rocks contain pebbles of large size, which have been proved by microscopical examination to be identical in character with the rocks on whose eroded surface they repose. Here again the marked similarity in the minutest particulars between the rolled fragments and the underlying rocks proves indisputably that the peculiar changes which these rocks have undergone must have taken place before the fragments were broken off, therefore in pre-Cambrian times.

MERIONETHSHIRE.

Harlech Mountain.—Near the centre of the well-known anticlinal of Cambrian rocks in the Harlech Mountain conglomerates are exposed which contain fragments of granitoid rocks, felstones, etc., in addition to pebbles of quartzites and quartz, and it is clear that they are, though not actually at the base, yet very near the base of the Cambrian rocks of that area. The most important conglomerates, however, in this district are those which were discovered by Professor Hughes and the author on the east side of the Trawsfynydd Road, between Cae Cochion and Penmaen. Here the conglomerates rest unconformably upon an older series of rocks, and large fragments of the latter occur plentifully in the conglomerates.

ANGLESEY.

As Sir A. Geikie has recently admitted that many of the rocks in Anglesey, coloured on the Geological Survey Map of that island as "altered Cambrian (and partly Silurian)," are "undoubtedly far older than at least any of the Cambrian rocks of Anglesey or Caernarvonshire," the evidence furnished by the basal beds where they rest on these rocks is highly important. The author was the first to point out, in a paper read before the British Association in 1879, that the patch near the centre of Anglesey coloured as "intrusive granite chiefly of Lower Silurian age" contained within its boundary rocks of pre-Cambrian age, evidently the oldest rocks in the island. (The rocks in this patch Sir A. Geikie now says appear to him to be "unquestionably Archæan.") In the year 1884 the author further showed that the Cambrian conglomerates near Llanfaelog contained large pebbles of granitoid and other rocks, which, on microscopical examination, proved to be identical with rocks *in situ* in their immediate neighbourhood.

Professor Hughes has shown by fossil evidence that the beds which overlie the conglomerates near Llanerchymedd are of Upper Cambrian age, and, as these are separated by faults from the conglomerates and grits, it is clearly justifiable to classify these beds as the basal beds of the Cambrian in that area. The basal Cambrian beds near Beaumaris furnish equally convincing proofs of proximity to a shore-line composed of pre-Cambrian schists and felsitic rocks.

CAERNARVONSHIRE.

Bangor and Caernarvon.—The basal beds at and near Caernarvon described by Professor Hughes show clearly that they must have been deposited along a shore-line where granitoid and felsitic rocks were undergoing denudation, and the absence there of the usual thickness of overlying Cambrian rocks is due, the author believes, mainly to faults, but in part also to the unevenness of the pre-Cambrian land-surface. There is much evidence in the various areas to show that the pre-Cambrian land-surface was very uneven in character, and that the Cambrian sediments were accumulated along fairly well-defined lines of depression.

Bethesda, Llyn Padarn, and Moel Tryfaen.—The basal beds of the Cambrian in these areas, where not removed by faults, are also conglomerates, and the fragments in the conglomerates are mainly such as would be derived by denudation from the ridge of rocks in the neighbourhood which had been claimed by the author and Professor Hughes as of pre-Cambrian age. These views, put forward by them in the year 1877, were not accepted by the chiefs of the Geological Survey; but in the year 1891, in his anniversary address to the Geological Society, Sir A. Geikie admitted that the rocks in this ridge, "variously termed quartz porphyries, felsites, and rhyolites," were not intrusive in the Cambrian rocks, as marked on the Survey Maps, but "the oldest members of the volcanic series," and that "there is no true passage of the sedimentary rocks into it; on the contrary, the conglomerates which abut against it are in great part made out of its fragments, so that it must have been already in existence before these Cambrian strata were deposited."

The grits and slates which overlie the conglomerates in these areas have always been classed by the Geological Survey as Lowest Cambrian; therefore any attempt on the part of the Geological Survey to extend the term Cambrian so that it might include the much older rocks which the surveyors had incorrectly marked as intrusive, and "chiefly of Lower Silurian age," the author thinks is unwarrantable. The error which caused the surveyors to class other pre-Cambrian rocks as "altered Cambrian" equally renders it impossible to group those with the Cambrian, especially as in no instance has it been shown that the so-called "altered Cambrian rocks" have their equivalents amongst the unaltered Cambrian rocks of the Survey. Moreover, it is certain that there is a marked unconformity at the base of the Cambrian (unaltered Cambrian of the Survey) in all the areas in Wales where the beds are seen to rest on the rocks classed by the author and others as of pre-Cambrian age.

II.—NOTES ON A HORNBLENDE-PIKRITE FROM GREYSTONES, CO. WICKLOW. By W. W. WATTS, M.A., F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

IN this paper the author gave a description of a rock which forms a dyke in the Cambrian slates and grits of Greystones, in Co. Wicklow. It is a dark, dense, coarsely-crystalline rock, showing large crystals of hornblende with lustre-mottling, owing to the weathering-out of olivine crystals. It becomes finer-grained at the margins. An analysis by Dr. Sullivan was added.

The hornblende is of the usual green type, and occurs in large crystals enclosing pseudomorphs of olivine, now made up of magnetite and probably a colourless amphibole. A colourless hornblende also occurs either as cores or borders to the green crystals. A third type of hornblende present shows few cleavage cracks and much magnetite dust. Apatite is a constituent, but there is no felspar in the rock. The margin of the dyke is much sheared and phacoidal in structure.

III.—NOTES ON THE PERLITIC QUARTZ GRAINS IN RHYOLITE. By W. W. WATTS, M.A., F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

THE author exhibited specimens of that variety of the Sandy Braes Rhyolite from County Antrim which was formerly called Perlite. A microscopical examination of the rock shows crystals of sanidine and grains of quartz embedded in a brown glass. The latter shows perlitic structure in great perfection. In addition, however, the grains of quartz exhibit a series of cracks, which are distinctly perlitic in character. Thus a structure which was supposed to be confined to glasses that have cooled rather rapidly is shown to occur rarely, but occasionally, in crystals. Hitherto only one case has been observed in which the cracks entered from the crystals to the matrix; the perlitic cracks in the two constituents are for the most part independent.

IV.—On the Minute Structure of the Skeleton of "Monograptus Priodon." By Professor W. J. Sollas, D.Sc., F.R.S. [Communicated by permission of the Director-General of the Geological Survey.]

REMAINS of *Monograptus priodon* in an exceptionally perfect state of preservation occur in the Silurian limestone of Barnham Hill, Co. Tipperary, and are exhibited in the official collection of the Geological Survey in Dublin. These have been examined in thin slices under the microscope, and as a preliminary result the author describes the structure of the wall.

Most of the sections are transverse and display the cœnosarcal canal and one hydrotheca; they measure a little over 1·5 mm. along the greater, and about 1 mm. along the shorter axis. The wall, 0·025 mm. in thickness, consists of black carbonaceous material in a more or less fragmentary condition, but sufficiently continuous to enable the existence of three layers to be determined: an outer and inner, which are very thin, separated by a space, now filled with calcite, from a thicker middle layer, which measures from 0·005 to 0·001 mm. across. The middle layer sometimes breaks up into threads, and the superficial films have a reticular appearance, which may, however, be due to *post-mortem* changes. In the region of the virgula and also along the free edges of the thecæ the wall thickens, partly by an enlargement of the space between the layers, and partly by a thickening of the middle layer. Thus, in one example the total thickness of the wall in the virgular region is 0·075 mm., and of the virgula itself, which represents the middle layer, 0·037 mm.; similarly at the margin of the theca the total thickness was found to be 0 085 mm., the included middle layer measuring 0·045 mm. Thin threads of carbonaceous material extend from the middle to the superficial layers, and are particularly obvious in the thickened regions. The virgula would appear to possess no independent existence; it seems to be merely a thickening of the middle layer.

V.—On the Origin of Intermediate Varieties of Igneous Rocks by Intrusion and Admixture, as observed at Barnavave, Carlingford. By Professor W. J. Sollas, D.Sc., F.R.S.

THE two principal kinds of Rocks composing the mountain of Barnavave are a dark-coloured, almost black, gabbro and a light-coloured, almost white, granophyre. This extreme contrast in colour renders the study of their relations to each other in the field a comparatively easy task. The gabbro, which overlies the granophyre, was the first-formed rock, and had already cooled and solidified before the granophyre was injected into it. The injection of granophyre has been of the most searching character, and the rock can be traced from the parent mass through dykes of all gradations in size down to the minutest films and specks which fill cracks and cavities in and amongst the constituent minerals of the gabbro. The gabbro has thus become converted locally into the quartz gabbro of authors, and it is suggested that in other cases, as that of Carrock Fell, this rock has had a similar origin. The granophyre, on the other hand, contains fragments of the gabbro, ranging from great blocks down to mere crystal dust of its constituent minerals, labradorite and augite. It thus passes into hornblendic granophyre, the "syenite" of the Survey. There is no evidence here, as has been erroneously supposed, of the differentiation of an originally homogeneous magma, and the minute granophyric dykes are neither contemporaneous nor segregation products. On the contrary, rocks of intermediate character have been produced from already differentiated and opposed types solely by admixture.

VI.—On the Discovery of a Concealed Ridge of pre-Carboniferous Rocks under the Trias of Netherseal, Leicestershire. By Professor Edward Hull, LL.D., F.R.S., F.G.S.

IT is now generally recognised that the Leicestershire and Warwickshire Coal-measures were deposited along the borders of a land surface of older Palæozoic rocks, of which the visible representatives occur at Charnwood Forest and Atherstone. The attenuated condition of the Lower Carboniferous beds at Calke Abbey on the north of the Leicestershire Coalfield, and their entire absence below the Coal-measures of Warwickshire, show that these older rocks remained unsubmerged till the commencement of the Upper Carboniferous period, when they were gradually overspread, as the land became depressed, by successive deposits of the Coal period. The general north-westerly trend of these old foundation rocks, both at Charnwood Forest and Atherstone, appears to indicate that this old land was composed of a succession of ridges and furrows running in N.W. and S.E. directions; but as the country is for the most part covered by Triassic strata the position of such ridges and hollows can only be determined by experiment. One of these ridges appears to have been in this manner determined at Netherseal Colliery in a boring put down for the purpose of determining the extension of "the main coal." Having been invited by Mr. G. J. Binns, F.G.S., the manager of the colliery, to give my opinion regarding the age of the beds passed through in the lower part of the boring, I visited the colliery and inspected the cores which were brought up and were arranged in their order of relative depth at the works. The following is an abstract of the strata passed through:—

TRIAS	*Bunter Sandstone*; light reddish-brown, pebbly sandstone; 262 feet.
COAL-MEASURES	Grey and black shales and sandstones, with coal and ironstone; plants abundant; 514 feet.
PRE-CARBONIFEROUS	Reddish, purple and grey grit, sandstone and micaceous quartzite; 19 feet.

The interest attaches to the beds called "pre-Carboniferous." They consist of sandstones, grits, and quartzites, of purple and yellowish tints, occasionally shaly. They contrast strongly with the Coal-measures, not only in the absence of beds of coal, grey and black shale, and ironstone, but also in the complete absence of plant remains with which the overlying Coal-measures are crowded; not one solitary instance of any plant-form having been found amongst all the cores after careful examination. It became clear that the beds were not of Carboniferous age, yet it was very difficult to determine with certainty to what period they were to be referred. Such sandstones, grits, and quartzites might be found in several pre-Carboniferous formations, either the Old Red Sandstone, the Upper Silurian, Lower Silurian (Ordovician), or Cambrian. A reference to the Old Red Sandstone was considered out of the question, as this formation is not found anywhere in this part of England; nor did it seem probable that they were referable to the Upper or Lower Silurian period, though this is possible. On the other hand, we could not forget that at no great distance to the south of the boring Lower Cambrian beds form the floor of the Coal-measures, and, although the cores at Netherseal boring did not show a very strong resemblance to those of the Hartshill ridge, there was no good reason why they might not be referable to the same general period, and consist of beds not visible in that locality. For these reasons I am disposed with some hesitation to regard the cores as of Lower Cambrian age, a view in which I am supported by Professor Lapworth, who was kind enough to examine the specimens of the cores which I brought away with me from Netherseal Colliery. I will only add that no conclusion could be gathered regarding the question of unconformity of these beds with the overlying Coal-measures, as the dip of both series appeared to be very slight. A strong discordance could have been immediately detected.

Since the above was written No. 2 boring has entered these old rocks, and the specimens brought up confirm the conclusion arrived at from the results of boring No. 1. The rock entered at a depth of about 760 feet consists of reddish vitreous quartzite, slightly micaceous, and very similar to the Hartshill stone of Warwickshire.

VII.—NOTES ON THE WATER-BEARING CAPACITY OF THE NEW RED SANDSTONE OF NOTTINGHAM. By Professor EDWARD HULL, LL.D., F.R.S., F.G.S.

ABOUT half a century ago, before the problems of sanitation were generally understood, the town of Nottingham was placed in a most unfavourable position as regards drainage and water-supply. As regards the former the drainage of the houses for the most part was run off into cesspools sunk in the sandstone rock on which the town is built; and as regards the latter the water-supply was drawn from wells sunk through the same formation down to the water-level, so that often the cesspools and wells were in proximity to each other. The result of such a state of affairs may easily be surmised. However excellent as a filter may be the sandstone rock, it must assuredly become clogged with fæcal matter when filtration of water is carried on for an indefinite period, subject to such contamination as is here referred to, and in course of time the water from the wells becomes unfit for drinking and household purposes.

Now all this is changed: the cesspools have been closed or filled up, and the water-supply is drawn from large and deep wells far removed from possibility of contamination.

Few towns in central England are more favourably situated for purposes of water-supply than Nottingham. Built on a foundation of New Red Sandstone and conglomerate, which rises at the Castle in a precipitous cliff above the valley of the Trent, the formation on which the city stands in its prolongation northwards is a source of water-supply of the highest excellence, and yields several millions of gallons per day of pure water from three or four wells situated within a few miles of the city.

The conditions which render this formation so well adapted for water-supply may be briefly explained. The succession and character of the strata all combine towards this end.

In descending order the succession is as follows:—

TRIAS	*Keuper Marls* . . .	Red and variegated marl, shaly and gypseous (slightly permeable).
	Waterstones and Lower Keuper Sandstone	Laminated micaceous sandstones alternating with marls and shales.
	Bunter Sandstone . .	Soft yellow and reddish sandstone and conglomerate (permeable).
PERMIAN	*Red Calcareous Marls* .	These are the strata separating the Upper and Lower limestones of the Worksop district to the north (impervious).
	Lower Magnesian Limestone	Sandy magnesian limestones.

From the above succession it will be seen that the permeable beds of the Bunter Sandstone, about 300 feet in thickness, are underlain by impervious marls of the Permian series, which thus form a water-tight floor, effectually preventing the water which percolates downwards from the surface to escape into the magnesian limestone; and, as the beds dip eastwards at a small angle from the western margin of the formation, an underground reservoir is thus formed with a naturally permanent level corresponding to that of the springs which break out at the junction of the sandstone with the marl along the western outcrop.

The proportion of the rainfall, taken at an average of 30 inches, which sinks down into the Bunter Sandstone north of Nottingham must be very large, owing to the absence of drift deposits and the sandy character of the ground. As there is no surface drainage the percolation cannot be less than about 20 inches per annum, giving a supply of about 1,000,000 gallons to every 3 square miles. Taking the area of the formation between Nottingham and Worksop at 120 square miles, the amount of water which annually percolates into the rock and becomes a reservoir of supply may be estimated at about 40,000,000 gallons per day.

This large quantity of water tends to flow eastwards, following the dip of the beds; and that it has permanently saturated the Bunter Sandstone under an extensive area occupied by the overlying formations is proved by the result of the boring at Scarle, near Lincoln, which, commencing in the Lower Lias, passed down through the Keuper marls into the Bunter, when the water came up with force and flowed over the surface.[1] This boring is at a minimum distance of 20 miles from the margin of the Bunter Sandstone. From these considerations it may be inferred that Nottingham is most favourably situated as regards its water-supply for a long period to come—a circumstance of great importance at a time when so many large manufacturing towns are looking forward with anxiety to the future as regards this prime necessary of progress and prosperity.

Since the above was written I have been favoured by Mr. L. T. Godfrey Evans, the Borough Engineer, with information, of which the following is a summary:—

There are four pumping stations, of which one, the Park, Zion Hill, is not now in use. The others are:—

1. Basford or Bagthorpe,	yielding	12,800,000	gallons per week.
2. Bestwood,	yielding	11,800,000	,, ,,
3. Papplewick,	yielding	12,190,000	,, ,,

In all 36,790,000 gallons per week, or 5,257,143 gallons per day.

The supply at Bestwood is decreasing, owing probably to mining operations in the neighbourhood. The yield at the Park Station is about 5½ millions of gallons per week. The water is excellent.

VIII.—On the Reptilia of the British Trias. By E. T. Newton, F.R.S., F.G.S.

THIS communication is a review of our knowledge of the reptiles which have been recorded from the Triassic strata of Britain. In the first place attention is called to the teeth from Durdham Down, Bristol, described by Riley and Stutchbury, in 1836, under the generic name of *Palæosaurus* and *Thecodontosaurus*, which, with additional specimens, were further described by Professor Huxley in 1869, he regarding them both as dinosaurian. The two genera are distinguished by the form of their teeth. Closely allied to *Palæosaurus* is the tooth described by Murchison and Strickland in 1837 as *Megalosaurus*, but subsequently named *Cladyodon* by Owen. Another and still larger tooth, from the same neighbourhood, has been referred by Professor Huxley to *Teratosaurus* (=*Zanclodon*): it is very similar to that of *Cladyodon*, but is more compressed and has both anterior and posterior edges serrated to the base.

---

[1] Two feeders of water were struck—one at a depth of 917 feet in the Lower Keuper Sandstone, and the other at 1,250 feet in the Bunter Sandstone.

Rhynchosaurus articeps, from the Keuper of Grinshill, Shropshire, was described by Owen in 1841 from a skull, but was further illustrated by additional specimens, including other parts of the skeleton, by Professor Huxley in 1887. This form, which is allied to the recent *Sphenodon*, is also near to the *Hyperodapedon*, remains of which have been found in the Elgin Sandstone and also in the Trias of Warwick and Devon. *Hyperodapedon* was first made known by Professor Huxley in 1858, who described it in 1869, but more fully in 1887, from a fine example preserved in the British Museum.

Telerpeton Elginense, the celebrated lizard of the Elgin Sandstone, was found in 1850 by Mr. Patrick Duff, and described by Dr. Mantell in 1851 as having amphibian affinities. Additional examples were, however, described by Professor Huxley in 1867, who showed that its affinities were with the lacertilia, and not with the amphibia. *Telerpeton* is probably closely related to the living *Sphenodon*. *Stagonolepis Robertsoni* was really the first reptile found in the Elgin Sandstone; a series of scutes from Lossiemouth being thus named by Agassiz just fifty years ago (1843), but were thought by him to be the scales of a fish. The reptilian nature of this fossil was shown by Professor Huxley in 1858, and more abundant material has been described by the same writer in 1875 and 1877, which has established the crocodilian affinities of this Triassic reptile.

Dasygnathus longidens is the name suggested by Professor Huxley for a jaw with long teeth from the Elgin Sandstone, which had at first been referred to *Stagonolepis*. This form Professor Huxley thought might be dinosaurian, but additional information is much wanted to establish its true affinities.

The dicynodont remains noticed by the present writer at the meeting of this Association last year at Edinburgh have now been worked out, and the results, fully illustrated, will shortly appear in the Phil. Trans. of the Royal Society. Four forms nearly allied to *Dicynodon* have been named *Gordonia Traquairi*, *G. Huxleyi*, *G. Duffiana*, and *G. Juddiana*. Another dicynodont more nearly related to the *Ptychognathus* of Owen, but with a short muzzle and no teeth, has been named *Geikia Elginensis*.

The peculiar horned reptile, resembling the Moloch lizard, but apparently most nearly related to the South African *Pareiasaurus*, has been named *Elginia mirabilis*.

Work among the Elgin reptiles is still going on, and two entirely new forms are now made known for the first time. One of these was found by Mr. James Grant, of Lossiemouth; and, although the exact locality is uncertain, there is no doubt as to its being from the sandstone of the Elgin area. This specimen, which includes the skull (about three inches long) and the fore part of the trunk, is evidently related to *Stagonolepis*.

The second new form was obtained by the Rev. Dr. Gordon from the Elgin Sandstone of Spynie Quarry, and will eventually be preserved in the British Museum. With the exception of the fore limbs and neck, nearly the whole of the skeleton has been preserved. Much of the skull has been very successfully cleared from the matrix by Mr. Richard Hall, of the British Museum, and was exhibited at a soirée of the Royal Society, when its resemblance to *Aëtosaurus* was pointed out by Mr. Arthur Smith Woodward. This reptile is of much interest, as it seems to be an intermediate form between crocodiles and dinosaurs, being, apparently, related on the one hand to the *Parasuchia* and on the other to the theropodous dinosaurs. The skull is, in fact, that of a miniature megalosaur.

IX.—NOTE ON SOME MOLLUSCAN REMAINS LATELY DISCOVERED IN THE ENGLISH KEUPER. By R. BULLEN NEWTON, F.G.S. British Museum (Natural History).

THIS communication directs attention to the discovery, by the Rev. P. B. Brodie and Mr. E. P. Richards, of some obscure impressions of lamellibranch shells in the green gritty marls of the Upper Keuper Sandstone of Shrewley, Warwickshire, which form the first evidence of a molluscan fauna from these beds as developed in this county. The matrix appears to be so peculiarly unfavourable for the retention of shell structure that it is doubtful whether any better material than the present will ever be forthcoming. The specimens indicate truly marine types, though on account of bad preservation only three of them could be selected for description as exhibiting certain characters in their contours and sculpturing, which might be of service in ascertaining their probable generic positions. *Estheria minuta* is the one invertebrate form hitherto recorded from the British Keuper; that is, excluding the Foraminifera described by Professor T. R. Jones and W. K. Parker,[1] which came from an alabaster pit at Chellaston, near Derby, and which were doubtfully referred by the authors to an Upper Triassic age. The very modern facies of the Foraminifera has suggested the highly probable idea that they were derived from superficial deposits.

Associated in the matrix containing these molluscan impressions are fragments of Cestraciont spines and teeth (*Acrodus Keuperinus*) and a part of a carapace of the small phyllopodous crustacean, *Estheria minuta*.

The specimens described are identified as—

(1) *Thracia* (?) *Brodiei* (n. sp.).
(2) *Goniomya Keuperina* (n. sp.).
(3) *Pholadomya* (?) *Richardsi* (n. sp.).

Such generic forms as are represented here have not apparently been reported from rocks of a similar period on the Continent or elsewhere.

---

[1] "On some Fossil Foraminifera from Chellaston, near Derby," Quart. Journ. Geol. Soc., 1860, vol. xvi. pls. 19, 20, pp. 452—458.

X.—ON THE RADIOLARIAN CHERTS OF CORNWALL. By HOWARD FOX, F.G.S.

THE Mullion Island Radiolarian cherts were first recognized by Mr. J. J. H. Teall, F.R.S., in rocks sent to him by the author last autumn, and a joint paper was read at the Geological Society's meeting, February 8 last, describing the manner in which they occur. Dr. Hinde accompanied the paper with a description of the species recognized and with micro-photographs of the individual organisms.

Last Easter Mr. Teall, Professor Lapworth, and the author traced these cherts for about 650 yards in the cliffs and on the foreshore from the south end of Nelly's Cove, near Porthallow, Meneage, to near Ligarath Point, south of the Nore Point. Subsequently the author has examined the coast and some inland districts between Helford River and Fowey, and has found other exposures in the following places:—

Pendoner Beach, Veryan (for about 1000 yards).—Beds many feet thick at the west end of this beach, on which the raised beach rests. Angular fragments of chert are enclosed in the raised beach, and in one place a mass of chert and slate cliff has been thrust over it, and thus the chert appears both above and below as well as in the raised beach. Towards the eastern end of this beach the chert beds become thicker and more numerous.

Portloe Point, Veryan.—Here several beds, varying from one to six inches in thickness, are seen for 20 yards in the volcanic breccia (or "trappean conglomerate" of De la Beche) associated with some small amount of shale and grit, more or less decomposing from the presence of iron. Two small exposures are traced inland, one of which is 500 yards west of Portloe Point.

Pecunnen Cove, Gorran.—North-west of the Dodman beds of chert are seen in perpendicular thinly laminated crushed-dark slates for 60 yards, accompanied by numerous lenticules and bands of black quartzite and yellowish-grey limestone.

Inland exposures are traced at intervals in a line extending for five miles inland from Pendoner Beach in a north-east direction through the village of Veryan to Tolcarne Mill, north of St. Michael Caerhays. These cherts on the mainland are less pure than those in Mullion Island, and the structure of the individual organism is destroyed. Some specimens show signs of great shearing and crushing, and have no traces of Radiolaria; others show shearing with slight traces of Radiolaria, whilst others show no signs of crushing, and have clear round spaces, evidently due to Radiolaria. In many of the specimens examined a considerable amount of ferric oxide has been formed by the decomposition and oxidation of pyrites, and possibly also of ferriferous carbonate. At Portloe Point the chert appears to pass into quartz.

The Meneage and Veryan cherts are associated with the well-known Ordovician quartzites of those districts, and appear to lie immediately under them; but the sequence is not absolutely clear, and no typical fossils have yet been found in the shales and slates with which the cherts are interbanded.

XI.—ON THE DERBYSHIRE TOADSTONE. By H. H. ARNOLD-BEMROSE, M.A., F.G.S.

TOADSTONE is a local name for the igneous rocks interbedded with the Carboniferous limestones of Derbyshire. It occurs in a district of 25 by 20 miles. The upper and lower portions of a bed are sometimes amygdaloidal. The spheroidal structure is often well marked, the columnar more seldom and less perfectly. Toadstone varies very much in the amount of weathering it has undergone. It often decomposes to a sort of clay containing nodules of less altered rock, so that it has been supposed that toadstone in some localities "replaces" a bed of clay in others. For this reason, and also because of the loose way in which the word is used by miners, statements as to the number of beds of toadstone and of the presence or absence of ore in it must be accepted with reserve. Careful mapping over the whole district will be necessary to ascertain the actual number of beds. Two at least may be seen exposed in several places, and there may be three or even four beds. The Black Hillock shaft has been supposed to be one of the vents through which the toadstone came up to the surface, because the bottom of the rock was not reached. Farey, however, maintains that this bed was sunk through, and a careful examination of the mine heap and shaft shows that the dolerite is not coarse-grained, and that there is no trace of agglomerate or tuff. An occurrence of lead-ore in the toadstone of the Wakebridge mine was next described. The rock in which the ore occurred, when examined under the microscope, proved to be a decomposed olivine-dolerite. The ore was as good in the toadstone as in the limestone. That the toadstone is contemporaneous with the limestone is proved by its being interbedded with the latter, by the occurrence of stratified tuffs in various parts of the district, and by the non-alteration of the beds immediately above the igneous rock, though in one or two places a clay bed below it has been caused to assume a columnar structure.

Very many specimens have been collected from all the outcrops of toadstone, which are some fifty in number, and many of them have been examined under the microscope. The lavas consist mainly of olivine-dolerite, the augite being both in ophitic plates and in irregularly shaped grains. The rock is much more fresh and less amygdaloidal than has been generally supposed. The tuffs are in some cases well preserved, and the outlines of the lapilli very clearly defined.

XII.—THE DISSECTED VOLCANO OF CRANDALL BASIN, WYOMING. By Professor JOSEPH PAXSON IDDINGS.

THE writer, in exploring the north-eastern corner of the Yellowstone National Park and the country east of it, came upon evidences of a great volcano which had been eroded in such a manner as to expose the geological structure of its basal portion.

The work was carried on as a part of the survey of this region under the charge of Mr. Arnold Hague, of the United States Geological Survey. This paper is an extract from a chapter of the final report on the Yellowstone National Park, in process of completion, and the writer is indebted to Major J. W. Powell, Director of the Survey, and to Mr. Hague, chief of the division, for permission to present it at this time in anticipation of the publication of the final report.

The area of volcanic rocks described is but a small portion of the great belt of igneous material that forms the mountains of the Absaroka range, lying along the eastern margin of the Yellowstone Park. The volcano of Crandall Basin is one of a chain of volcanic centres situated along the northern and eastern borders of the Yellowstone Park, which are all distinguished by a greater or less development of radiating dykes, and by a crystalline core eroded to a variable extent.

The Palæozoic and Mesozoic strata, which formed an almost continuous series to the coal-bearing Laramie, had been greatly disturbed, and almost completely eroded in places, before the volcanic ejectamenta in this vicinity were thrown upon them. The period of their eruption is therefore post-Laramie, presumably early Tertiary.

The first eruptions of andesite were followed by those of basalt in great quantities, and these by others of andesite and basalt, like the first. This was succeeded by a period of extensive erosion, reducing the country to nearly its present form. Then came the eruption of a vast flood of rhyolite, constituting the Park Plateau, which was followed, in this region, by smaller outbreaks of basalt. The last phase of volcanic activity is found in the geysers and fumaroles which have rendered the region famous.

The volcano of Crandall Basin consists chiefly of the first series of basic andesites and basalts. The earliest acid andesite which occurs beneath these rocks appears to be the remnant of eruptions from neighbouring centres.

Nothing remains of the original outline of the volcano. The district is now covered by systems of valleys and ridges of mountain peaks that rise 2,000 to 5,000 feet above the valley bottoms. The geological structure of the country, however, makes its original character evident.

The outlying portions of the district to the south, west, and north consist of nearly horizontally bedded tuffs and subaërial breccias of basic andesite and basalt. With these are intercalated some massive lava-flows, which are scarce in the lower parts of the breccia, but predominate in the highest parts above an altitude of 10,000 feet. Here they constitute the summits of the highest peaks.

In contrast to the well-bedded breccias around the margin of the district the central portion consists of chaotic and orderless accumulations of scoriaceous breccia with some massive flows. These breccias carry larger fragments of rock and exhibit greater uniformity in petrographical character.

A still more noticeable feature of the central portion of the district is the occurrence of dykes, which form prominent walls, and may be traced for long distances across the country.

The greater number of them converge towards a centre in the highest ridge in the middle of the drainage basin of Crandall Creek. A small number converge towards a second centre three or four miles east of the first. In the southern part of the district there are many dykes trending towards a centre near the head of Sunlight Basin, about fifteen miles south of the Crandall centre.

The centre towards which the Crandall dykes converge is a large body of granular gabbro graduating into diorite. It is about a mile wide, and consists of numerous intrusions penetrating one another, and extending out into the surrounding breccia, which is highly indurated and metamorphosed in the immediate vicinity of the core. Within the area of indurated breccia the dyke-rocks become rapidly coarser-grained as they approach the gabbro core. This was undoubtedly the central conduit of an ancient volcano, the upper portion of which has been eroded away.

Upon comparing the geological structure of this region with that of an active volcano like Etna it is apparent that the lava-flows which form the summits of the outlying peaks must have been derived from lateral cones fed by dykes radiating from the central conduit; and, assuming that the volcano of Crandall Basin was similar in type to that of Etna, an idea of its original proportions is derived by constructing, upon profile sections through the Crandall core, the outline of Etna. If the erosion of the summits of the highest peaks is neglected the resulting height of the ancient volcano above the limestone floor is estimated at 13,400 feet. This is undoubtedly too low, and is well within the limits of present active volcanoes.

Erosion has removed at least 10,000 feet from the summit of the mountain to the top of the high central ridge in which the granular core is situated, and has cut 4,000 feet deeper into the valleys on either side. It has prepared for study a dissected volcano, which, it is hoped, will in time reveal some of the obscurer relationships existing between various phases of igneous rocks.

XIII.—Geological Sketch of Central East Africa. By Walcot Gibson, F.G.S.

THE tract of country described in this paper is situated in Equatorial East Africa. It extends from the coast inland to the N.W. borders of Victoria Nyanza.

The small island of Mombasa, the starting-point of the expedition, lies fitfy miles north of the island of Pemba. A narrow creek, fordable at low water, separates the island from the mainland.

The sea cliffs are composed of coral rock, which also forms an inland belt about two miles broad, with a general elevation of 50 feet, which sometimes rises to 100 feet. A fringing reef borders the coast. The shore sand consists of comminuted corals and shells mixed with rounded fragments of quartz, orthoclase, garnets, and splinters of clear blue cyanite. These constituents appear to be derived from a submerged ridge, of which the Seychelles Islands are a remnant.

The coral rock rests on a sedimentary series consisting of shales, limestones, flaggy sandstones, grits, and conglomerates in descending order. The beds dip gently to the east. They extend inland to the borders of the Taru Plain, a distance of about forty-seven miles.

The beds are of marine origin, Ammonites and Ichthyosaurian remains having been found near Rabai and other localities.

It is impossible to correlate these beds with any occurring in South Africa, but they appear to form a belt running many miles north and south of Mombasa.

The sedimentary beds rest unconformably on a metamorphic series, consisting of gneisses, schists, and intrusive granites. The strike is N.N.W. and S.S.E., and the dip is generally high. The beds are often intensely folded (Ndange River). Biotite is the commonest mica, and orthoclase the predominant felspar. The schists contain much cyanite, full of iron inclusions. Common garnets are plentiful. Hornblendic rocks are remarkably scarce, the main mass being micaceous. Graphite schists occur, and the Bura Hills are largely composed of a crystalline limestone containing scales of graphite. No fossils could be detected. Quartz veins and quartzites are only feebly developed. They form gently undulating country or else nearly level plains (Taru, Serengeti) through which low isolated hills of gneiss and granite protrude.

It is evident that they have suffered enormous denudation. They no doubt represent a complex metamorphosed series of sediments and intrusive rocks, but of what geological age or ages it is impossible to state.

The intrusive granites are generally pegmatites. Porphyritic granite covers a large area in Kavirondo. Biotite is the essential mica, and a pink orthoclase the predominant felspar. The relation of this large mass of granite to the gneisses and schists could not be ascertained.

The area covered by granite and metamorphic rocks is enormous. Fully two-thirds of Central East Africa are composed of these rocks. The remaining portion of the country, excepting the narrow coast belt of sedimentary rocks, is formed of recent volcanic rocks.

No traces of the fossiliferous sandstones and shales found by Professor Drummond near Lake Tanganyika, and quite recently by Mr. Joseph Thomson to the west of Lake Nyassa and around Lake Bangweolo, were detected. If further investigation proves their absence from East Africa to be a fact, then we have in the deposits around Lake Tanganyika the most northerly extension of the Karoo beds of South Africa.

Volcanic rocks form the grandest scenery in East Africa. They occur in two forms, giving rise to two distinct types of scenery. They have either built up tall isolated mountains like Kilimanjaro (19,718 ft.), Kenia (18,000 ft.), Elgon (14,000 ft.), Chibchangani (12,000 ft.), besides numerous other smaller hills, or they are arranged in lines running north and south. The lavas, tuffs, and ashes composing the high central plateaux of Mau, Kamasia, and Lykipia have evidently issued from a north and south fissure. The site of this fissure is now occupied by the chain of lakes commencing with Naivasha on the south, and terminating northward in Lake Baringo. Along this line recent eruptions, some still giving out steam, have broken out, and it is the interception of the drainage by the material thrown out from these vents that forms the lakes Naivasha, Nakuru, and Elmeteita.

Highly acid and ultra-basic rocks are represented. Kilimanjaro and the Kyulu Mountains are chiefly built up of basic rocks, while the lavas of Lykipia and the Mau plateaux are chiefly acid. It appears that the latter localities have been the seat from which acid lavas have continued to be poured from times prior to the first eruptions of Kilimanjaro up to the present day.

The basic lavas of Kilimanjaro do not extend very far from the original point of issue. At least this is so to the north, for no lavas were found on the plains of Lytokitok, distant thirty miles north of Kilimanjaro. On the other hand the acid lavas of Mau and Lykipia extend for great distances. Eastwards they stretch as far as the Athé plain, about fifty miles, and westwards to near the shores of Victoria Nyanza, a distance of nearly one hundred miles.

Further westward, in Busoga and Buganda, basic igneous rocks pierce the metamorphic rocks, but without possessing any general trend.

With the exception of the still active volcanoes it is impossible to state even the approximate geological age of any of the eruptions. Some of the volcanoes are possibly only dormant, others are certainly extinct, but none appear to be of great geological antiquity. All that can be safely asserted is that they are long subsequent to the deposition of strata containing *Ammonites*, for, whereas the conglomerates of these sedimentary deposits contain pebbles of schist and gneiss, they nowhere yield fragments of igneous or volcanic rocks.

REVIEWS.

I.—NOTE SUR LES GÎTES DE PHOSPHATE DE CHAUX DES ENVIRONS DE FRESNOY-LE-GRAND. Par M. GOSSELET. Annales de la Soc. Géol. du Nord, vol. xxi. 1893, pp. 149–159.

IN this paper Prof. Gosselet describes the position and mode of occurrence of some newly opened deposits of phosphate of lime near Fresnoy-le-Grand, in the north of France. The workable deposits do not extend over areas of more than from five to ten acres in each locality, they occur in a zone of Gray Chalk of from 1½ to 2 metres in thickness, containing *Belemnitella quadrata*, *Ventriculites* and sharks' teeth. The phosphate is partly in the form of concretionary nodules, which are so numerous as to form a sort of conglomerate in the lower portion of the bed; the phosphate varies in amount from 9 per cent. to 27 per cent. The Gray Chalk rests on White Chalk with *Micraster coranguinum,* and the upper part of this latter is penetrated just below the line of junction for about 1 m. in depth, by pockets and branching cylindrical or elliptical pipes filled with rich phosphatic chalk, and in places there is an apparent breccia between the two beds, in which the fragments of White Chalk have sharp angles, and form but a small proportion of the whole mass.

The gray bed of phosphatic chalk is overlaid in places also by White Chalk in which there are likewise some grains of phosphate, in places by Tertiary deposits. In some areas the gray bed crops out near the surface, and it then sometimes contains pockets of phosphatic sand.

II.—REPUBLICATION OF CONRAD'S FOSSIL SHELLS OF THE TERTIARY FORMATIONS OF NORTH AMERICA. By G. D. HARRIS. (Washington, 1893.)

REPUBLICATION OF CONRAD'S FOSSILS OF THE MEDIAL TERTIARY OF THE UNITED STATES. With an Introduction by Dr. W. H. DALL. (Philadelphia, 1893.)

IN republishing the above works of Conrad, Messrs. Dall and Harris have rendered an immense service to students of the Mollusca. The first mentioned book was published in parts, which only exist at the present day in a more or less fragmentary condition. The dates of their issue were practically unknown until Dr. Dall, with infinite pains and research, succeeded in establishing the same;[1] whilst Mr. Harris was subsequently enabled to make some further notes thereon.[2] The former author remarks that "Mr. Conrad had several peculiarities; he wrote his letters and labels frequently on all sorts of scraps of paper, generally without date or location. He was naturally careless or unmethodical, and his citations of other authors' works cannot safely be trusted without verification, and are usually incomplete. He had a very poor memory, and on several occasions had re-described his own species. This defect increased with age, and, while no question of wilful misstatement need arise, made it impossible to place implicit confidence in his own recollections of such matters as dates of publication."

Conrad's method of publication, too, was slovenly in the extreme. The "Medial Tertiary" volume, also issued in parts, had blank spaces left on the covers for the purpose of filling in the number of each part and the date of its publication—these particulars being written with a pen, presumably by the author. Sometimes when there were a few diagnoses over, enough to fill a "signature" of 8 or 16 pages, the excess was printed on the cover, and occasionally the cover of one and the same part was twice surcharged. It would seem from Dr. Dall's observations that the sheets were kept on hand and made up into a volume when called for from time to time by the subscribers. In regard to the plates in the work, it appears that, owing to the vagaries of the authors, there is at least one plate which is not the original, but a substitute, in nearly every copy extant.

---

[1] Bull. Phil. Soc. Wash. vol. xii. (1893), pp. 215–239.

[2] American Geologist, vol. xi. (1893), p. 279.

Many of the fossils are re-figured and partially described by the Marquis de Gregorio[1]—those from the Middle Eocene of Claiborne, Alabama—but the drawings are not well done. In the two works under review we have *fac-simile* illustrations, whilst the text is a "Chinese copy" of Conrad's own. The only additions are the editors' introductory remarks and a useful index of genera and species to each volume.

III.—Report on the Bendigo Gold-Field. By E. J. Dunn, F.G.S. Folio, pp. 20, with numerous Plans and Sections. (Melbourne, 1893.)

THIS is one of the "Special Reports" of the Department of Mines, Victoria. The object kept in view in this elaborate and well illustrated Report, by the painstaking Surveyor, is to indicate the direction and the extent, both longitudinal and transverse, of the known "reefs," or lines of outcrop and underground foldings, of the gold-bearing rocks, so that the miners might carry on their operations not empirically, but with a real knowledge of the relative position of these rocks, whether seen or not at the surface, or in the existing mines and borings. Thus the miner may often make sure of working progressively for a considerable distance ahead of his present shaft and adits, along the axial lines of the anticlines and synclines, now here indicated by clear plans and sections, as well as where and how to follow the slopes ("lines of pitch") of the bent or folded strata with advantage.

The special rocks of these saddles and troughs being known, they can be recognized in the "cross-cuts," and "it will be possible to locate the precise zones of rocks through which work is contemplated over the whole field."

Had such practical geological knowledge as is here placed at the command of the miners been appreciated and possessed by them, in Australia and elsewhere, in time past, it would have saved enormous waste of time, labour, and lives.

IV.—Lehrbuch der Petrographie. Von Dr. Ferdinand Zirkel; Zweite gänzlich neu verfasste Auflage. Erster Band. Leipzig (Wilhelm Engelmann), 1893.

THE twenty-seven years, which have elapsed since the last edition of this important work was published, have been extremely prolific so far as writings on petrographical subjects are concerned. It is, therefore, not surprising to find that the present edition, which is to consist of three volumes, will largely exceed the last in size. If the second and third volumes are each equal to the one now before us, then the new edition will contain three times as much matter as the old one. This increase in size is certainly not out of proportion to the increase in our knowledge.

---

[1] Ann. de Géol. et Pal. (Palermo), 7^e and 8^e liv. (1890).

The brilliant results achieved by the application of the microscope to the study of rocks led, at first, to the comparative neglect of the older methods of investigation; but the time has passed by when the description of the microscopic characters of isolated rock-specimens can be of much value. The microscope has now to be employed in conjunction with the chemical balance, and both must be brought to bear on rocks whose relations with other rocks have been carefully studied in the field. Petrographical students will, therefore, cordially welcome the appearance of a work in which rocks are to be treated from all points of view. Professor Zirkel has set himself the task of recording the present state of petrographical science. He has an extensive acquaintance with rocks, both in the field and in the laboratory, and an unrivalled knowledge of the literature of the subject. He is, moreover, in other respects eminently qualified to carry out the work he has taken in hand, and there can be no doubt that the present edition of his well known treatise will be constantly consulted by all those who are engaged in petrographical research.

The first part deals with General Petrography. The methods employed in the investigation of rocks are first described. Then follows an account of the mode of development of the constituents and a detailed description of each of the important rock-forming minerals. The information on these topics is brought well up to date, and there are copious references to original papers.

Rock-structures and the mode of occurrence of rocks as parts of the earth's crust are next considered; and, after describing the various agencies by which rocks are altered, the author concludes the first part of his work with a broad general classification.

As regards the technical terminology of the science, the author is content in most cases to accept the terms already in use. He, however, frequently objects to those employed by Rosenbusch. Thus instead of *idiomorphic* and *allotriomorphic*, which are extensively employed both in Germany and in English-speaking countries, he prefers the older terms *automorphic* and *xenomorphic* first proposed by Rohrbach. He also protests strongly, both on historical and etymological grounds, against the use of the term *granophyre* in the sense in which it is employed by Rosenbusch. It must be admitted that there is great force in many of his arguments; but, after all, the main object of language is to convey clear and definite ideas, and if this result be obtained there are many who are prepared to tolerate a little historical injustice and even some etymological inaccuracy. No scientific man ever dreams of arriving at the meaning of a technical term by considering its etymology.

The author separates rocks into four groups for descriptive purposes:—

I. Massive eruptive rocks.

II. Crystalline schists.

III. Sedimentary rocks with crystalline (at least not clastic) structures.

IV. Clastic rocks.

This is probably as good a classification as any that could be devised. Inasmuch as rocks do not fall into sharply-defined natural groups, it is impossible to invent a classification against which objections may not be urged.

The subjects referred to above occupy three-fourths (635 pages) of the present volume. The remainder forms an introduction to the detailed study of the igneous rocks. Mode of occurrence is first discussed, and it is satisfactory to note that the true significance of the contrast in structure between the volcanic and plutonic rocks is clearly recognized. The attempt of Rosenbusch to raise the dyke-rocks to the position of a group, comparable in importance to the plutonic and volcanic groups, is unfavourably criticised. The minerals which enter into the composition of igneous rocks are next considered, especially with reference to the laws of association. Microscopic research has led to important modifications in the old ideas as to paragenesis, but there are many laws relating to the association of minerals which possess a sufficient amount of generality to make them worthy of most careful consideration.

The chemical relations of igneous rocks are discussed at length, and the views of Bunsen von Waltershausen, Durocher, Rosenbusch, H. O. Lang, Lagorio, Iddings, and others are fully described and critically examined. The phenomena attending the consolidation of igneous magmas are most carefully considered and the constituents are classified as follows, with regard to their order of development:—

1. Minerals foreign to the eruptive magma.
2. Minerals produced before the normal consolidation of the mass; *e.g.* quartz in quartz-basalts.
3. Minerals due to the action of the magma on the constituents belonging to 1 and 2.
4. Minerals formed as products of normal consolidation.
5. Minerals formed during the last stages of consolidation, which, however, can scarcely be regarded as belonging to the ordinary processes of consolidation; *e.g.* tridymite and fayalite in lithophysæ in obsidian, etc.
6. Minerals which do not belong to any of the above categories, and which cannot be referred to 7 with certainty.
7. Minerals produced in the rocks after consolidation by secondary agencies, or deposited in cavities by infiltration.

In dealing with the classification of the igneous rocks, the author lays down the general principle that mineralogical composition and structure are the two factors of primary importance. He thinks that geological age may still be employed in certain districts, and no doubt he is right; but whether it is desirable so to employ it in a general classification is a question on which difference of opinion still exists. The classification ultimately adopted is very similar to that of the first edition, except that geological age is relegated to a secondary place. The felspathic constituents are used as the means of defining the principal subdivisions, and three main groups are recognized. The first includes the rocks characterized by the predominance of alkali-felspars, the second those characterized by lime-soda-felspars, and the third those containing no felspar. These are further subdivided according to the presence or absence of quartz and the nature of the felspathic and ferro-magnesian constituents. Two main divisions—the granular and the porphyritic (including glassy) — based on structure are recognised. These correspond approximately, but not exactly, with the plutonic and volcanic divisions of other authors. Geological age is introduced, as in the Rosenbusch classification, only with reference to the volcanic rocks. The limitation of the terms rhyolite, andesite and basalt to rocks of the Tertiary and post-Tertiary periods will strike anyone acquainted with British rocks as very strange and unnatural.

The value of this work, however, does not depend on the classification which is adopted or on the terminology employed; but on its being an encyclopædic record of the present state of petrographical knowledge. In many cases the student will find here all that he wants, but if not he will have no difficulty in obtaining references to the original communications bearing on the subject in which he is immediately interested. The second and third volumes are promised within a month or two.

V.—OBSERVATIONS AND EXPERIMENTS ON THE FLUCTUATIONS IN THE LEVEL AND RATE OF MOVEMENT OF GROUND-WATER ON THE WISCONSIN AGRICULTURAL EXPERIMENT STATION FARM, AND AT WHITEWATER, WISCONSIN. By Prof. FRANKLIN H. KING, United States Department of Agriculture, Weather Bureau, Bulletin No. 5 (1892). 75 pp., six plates.

THE experiment farm lies on the south side of Lake Mendota, in Wisconsin. The ground rises from the level of the lake to about fifty feet above it, within the area in which the wells are situated, and just outside that area to a height of 111 feet. The farm is situated on Till, resting on an uneven surface of Madison sandstone. All over the surface of the ground there is a layer of reddish clay, 2½ to 4 feet thick, containing pebbles and boulders sparsely scattered, which passes rather rapidly downwards into a nearly uniform sand. The wells are 54 in number, and the majority vary in depth from 5 to 26 feet and are made wholly in the Till, but a small number reach a greater depth and penetrate a few feet into the rock. Most of them are tubed with 5-inch drainage tile, surmounted at the surface with one length of 8-inch glazed sewer pipe with a galvanised iron cover. The height of the water in the wells was at first ascertained by lowering a weight through a distance which could be measured by a micrometer on the surface, the base of the weight being a hemispherical button which produced waves in the water at the instant of contact. Afterwards a simple recording instrument was employed, consisting of a copper float connected with the short arm of a lever, the long arm of which carried a pen which, on a scale three times the natural size, traced the fluctuations in the water-level on paper moved by clockwork.

The level at which the water stands in the wells is everywhere above that of the water in Lake Mendota. The general tendency, as is observed in other places, is to stand highest under the highest ground, but to this there are several notable exceptions. When a prolonged dry period is followed by heavy rains, the water-surface under the low lands not infrequently stands above that under the higher areas. This is due partly to the low lands having less storage capacity on account of their smaller depth of soil, partly to the rains remaining for too short a time on the high lands to penetrate the soil. The measured height of water in a well is not always, however, a true index of the level of the neighbouring ground-water. It may be below the latter if the well be in constant use; and above it occasionally after protracted heavy rains, when the soil-air is unable to escape readily upwards through the supersaturated surface, but can be forced out of the wells, thus allowing the water to follow it.

The rate at which the ground-water rises and falls varies between rather wide limits, but, as a rule, a given rise occupies a much shorter time than the same fall. The water generally falls more rapidly in the shallow than in the deep wells, partly on account of the shorter distance to the drainage outlet making the resistance to the flow less, partly from a more rapid loss of water at the surface of the ground through combined capillary and root action. After a fall of rain the rise of the ground-water takes place almost immediately in the shallow wells, but lags behind for two or three days in the deep ones, the average rise being 0·42 foot, or about five inches, for a rainfall of one inch. The rate at which the water-level falls is much greater when the barometer is rising than when it is falling; during the three years 1888–90 the mean daily fall was 0·224 inch with a rising, and 0·001 inch with a falling, barometer. Again, the water-level falls more rapidly during the day than during the night, the average fall for a number of wells being 8·583 inches per 1000 day-hours (6 a.m. to 6 p.m.) and 1·309 inches per 1000 night-hours (6 p.m. to 6 a.m.).

The general surface of the ground-water is also subject to numerous oscillations of small extent, some of which are almost microscopic in amplitude, so that it is rare for it to be ever quite at rest. "The equilibrium of the water in the capillary soil-spaces above the surface of the ground-water is so unstable that apparently the slightest cause is sufficient to upset it, causing the water to flow out into the non-capillary spaces, but only to be returned again, often on a moment's notice. . . . . The geologic and agricultural significance of these movements must be very great, for here is a water-washed zone of rock and soil, having the combined area of all land above the ocean level, unless we must except those of the polar zones, which is alternately flooded with water and then exposed to air; and this zone, rising and falling through greater and lesser distances, according to the secular and short period changes in the level of the ground-water, must greatly exaggerate the solvent power of soil-water over what it would be did these oscillations not exist" (p. 44).

Barometric changes, for example, exert a very marked and nearly, if not quite, immediate influence on the level of water in wells, especially those changes which take place suddenly, for the effects of long period barometric oscillations may be masked by other movements. A rise in the barometer is associated with a fall in well-water, and also with a diminution in the rate of flow of water from tile-drains, springs, and artesian wells, even from a well 979 feet deep. Semi-diurnal changes of level are also perceptible, a major minimum occurring from 7 to 10 a.m. and a minor one from 9 to 11 p.m., coinciding therefore in time with the maxima of the semi-diurnal barometric period. There appear to be two very different causes to which these movements may be attributed—(1) The general level of the ground-water may be depressed bodily by a rise of barometric pressure, and *vice versâ*, just as would be the case with the ocean surface with a change in the distribution of pressure. Or (2) when the barometer falls, the expansion of the air escaping from the water, and of that which exists in the interstitial soil-spaces above the ground-water, may force the capillary water out into the wells and drainage channels, the rarefaction of the soil-air allowing the return of the water into the passage-ways when the barometric conditions are reversed.

Changes in the temperature of the soil also produce changes in the level of the water-surface, the surface rising with an increase of temperature, and *vice versâ*; possibly in part from the expansion and contraction of the air which occupies the capillary spaces of the soil.

Heavily-laden railway-trains passing at a distance of 140 feet from one of the wells produced a rapid but gradual rise of the water of about $\frac{1}{10}$ of an inch, followed by a slightly less rapid fall again to the normal level. It is doubtful whether this is due to the compression of the earth by the weight of the train and consequent lateral displacement of the ground-water, or to the water being forced out of the capillary spaces just above the ground-water surface. The phenomena may, in any case, have some bearing on the movements of water in wells during earthquakes.

Lastly, these experiments have shown that the general impression that water cannot percolate through frozen soil is not quite correct. During three consecutive winters, at times of sudden thaws or winter rains, water has been observed to find its way through the frozen ground, probably by shrinkage cracks and worm burrows, into the drains and shallow wells of the experiment farm.

C. DAVISON.

VI.—ELEMENTARY PALÆONTOLOGY FOR GEOLOGICAL STUDENTS, by HENRY WOODS, B.A., F.G.S. Small 8vo. pp. vi. and 222, with 56 figures in the text. Cambridge Natural Science Manuals. Cambridge University Press. (October, 1893.)

ERROR is deathless; and an educational humorist once remarked that each new Text-book was a compilation of the mistakes of all its predecessors, with a few added on its own account. We thought he was joking; but the truth probably is that he had just read a manual of Elementary Palæontology from the pen of Mr. H. Woods. The errors in this book may be divided into inherited and original. We select a few specimens from either class.

On page 2 it is stated that no remains of *Rhytina gigas* are found in the rocks. Reference to Dr. H. Woodward's paper (Quart. Journ. Geol. Soc. vol. xli. p. 457) would have shown that they are found nowhere else, while a glance at the labelled specimen in the British Museum would equally have shown the incorrectness of the statement, which we presume is original.

On page 12 *Nautilus* is said to extend from the Ordovician to the present day. This error, inherited from a dim antiquity, might have been avoided by looking at A. H. Foord's Catalogue of Fossil Cephalopoda in the British Museum (table on page xix.).

As for the geological ranges assigned in this manual to various genera of the Mollusca, it can only be said that the author's ideas of what should be included under those genera are too broad-minded to be of much scientific value. It is clear, for instance, that under *Cerithium* the whole of the true Cerithidæ are included, and, since there is no indication of the many sub-genera (or genera, as we should prefer to term them), the student hardly knows what meaning he should attach to statements about the genus. Indeed, in his molluscan nomenclature the author strangely ignores all the modern work on the subject.

On page 67 the remarks on the pedicellariæ of Asteroidea would have been better applied to those of Echinoidea, which are of a different character.

On page 85 errors bristle; *e.g.* "Cup" and "Calyx" are not interchangeable terms; "Disc" has never been used in the sense here applied to it; the arms of a Crinoid are hardly "soft parts"; pinnules are absent in a very large number of Palæozoic Crinoids; and so on.

On pages 88, 89 the exploded absurdity of a soft disc roofed over by a solid vault and the obsolete classification into Palæocrinoidea and Neocrinoidea are maintained, although Mr. Woods might have discovered the truth from the GEOLOGICAL MAGAZINE for May, 1891 (Dec. III. Vol. VIII. p. 220), or even from Nicholson and Lydekker's Manual of Palæontology (1889), which we notice that he has drawn upon in other instances. Why, out of the four genera chosen for description, three should be such aberrant forms as *Crotalocrinus*, *Apiocrinus* and *Marsupites*, we cannot imagine. This is originality with a vengeance.

Page 108.—This is a detail; but does a Cambridge man who knows the meaning of *dioeceous* (*sic*) really think that *umbone* is the singular of *umbones*?

To say, as is done on page 175, that the septal necks of Ammonoidea (except *Clymenia* and *Goniatites*) are directed forwards, is somewhat too broad a statement, whatever construction be put upon it; while the announcement that "in the Palæozoic the only genera [of Ammonoidea] are *Goniatites*, *Clymenia* and *Ammonites*" is, if not original, startlingly retrogressive. Originality must undoubtedly be claimed for the "diagram-section" of *Belemnites,* page 179, which, in its peculiarly projecting collar, reminds one of a well-known political caricature.

We do not, of course, deny that, after eliminating these and similar slips, there remains a residuum of truth. The chapters on Foraminifera and Sponges, for instance, seem to have passed under a revising eye. But the method of residues, though useful enough to the chemical investigator, is of no great advantage to the student of palæontology. We should not have devoted so much space to pointing out the failings of the book, had we been able to discover anything in it that made up for them. One does not expect great things from an elementary manual; but *it must be correct.*

The list of works to which the student is directed will, however, enable him easily to rectify the errors of the manual itself. It would be ungracious to object to the inclusion of certain names in this list, since they at least give it a flavour of respectability; but we may be allowed to wonder why others have been omitted. Surely Mr. Woods does not wish to keep his students in ignorance of Malcolm Laurie's studies on the Eurypterida; and why is no mention made of the leading authorities on fossil Crinoids—P. H. Carpenter and Wachsmuth and Springer?

To conclude: for these 222 small pages of large type the University of Cambridge ask the student to pay six shillings. This will at least check the circulation of the book, a result that not even the author dare deplore. G. F. H., F. A. B.

VII.—*Ueber Æpyornis.* By R. Burckhardt. Palæontologische Abhandlungen. Neue Folge. Band II. Heft 2. (Jena, 1893.)

In this memoir the author gives an account of some remains of *Æpyornis* collected by Hildebrandt near Sirabé, in Central Madagascar, during the year 1880, and now deposited in the Mineralogische Museum in Berlin.

The special interest of the paper lies in the fact that in it we have, for the first time, a description and figures of the pelvis, an immature metatarsus, and a complete fully adult specimen of the same bone, of which the proximal end was previously unknown. The collection also includes a complete tibia, an imperfect femur, some vertebræ and fragments of ribs. The author considers that these bones belong to a new species (*Æ. Hildebrandti*), intermediate in size between the *Æ. medius* and *Æ. modestus* of Milne-Edwards.

The pelvis, the most important of the specimens described, possesses the following characters: (1) The whole of the constituent bones unite without trace of suture. (2) The post-sacral vertebræ are much reduced in size. (3) The bulk of the pelvis lies in front of the acetabulum. (4) The axis of the pelvic vertebræ at first runs straight back, then, from vertebræ 7–12, opposite the acetabulum it forms a strong ventral convexity, behind which the reduced post-sacral vertebræ slope away dorsalwards. (5) There is a pre-acetabular process. (6) The ischium, which is convex outwards, consists of a thickened central axis with dorsal and ventral wings. The post-sacral connection is ligamentous.

The proximal articular surface of the metatarsus has no intercondylar process, but instead there is a shallow median groove which receives a ridge on the distal end of the tibio-tarsus, between the condyles. In the immature metatarsus, the fourth metatarsal is more weakly developed than the others, at least at the upper end.

After an exhaustive comparison of the osteological characters of *Æpyornis* with those of the other Ratites, the author comes to the conclusion that the Æpyornithidæ constitute a distinct family, having no near relations, and being highly specialized and characterized by the massive structure of the skeleton accompanied by the pneumaticity of some of its parts. The resemblances with the Dinornithidæ he regards as superficial and merely the result of convergence due to similar conditions of life; on the other hand, the differences are considered to be of great importance, *e.g.* the pneumaticity of the femur, which, among the Ratitæ, occurs in *Æpyornis* and *Struthio* alone. *Struthio* also resembles *Æpyornis* in some other respects, *e.g.* the structure of the egg-shell, so that on the whole the relationship between them is regarded as less remote than that existing between the Æpyornithidæ and the other Ratite families. In conclusion, it is suggested that the Dromaeidæ and Casuaridæ, which, especially the former, are, in some respects, the least specialized Ratites, may be the recent representatives of a parent stock, from which, on the east, arose the Dinornithidæ and Apteryx; while, on the west, the ancestors of *Struthio* and *Æpyornis* branched off, the former making their way into Africa through India and Arabia, the latter reaching Madagascar by way of Southern India.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 8th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "The Geology of Bathurst, New South Wales." By W. J. Clunies Ross, Esq., B.Sc., F.G.S.

After sketching the physiography of the Bathurst district, the author describes in detail its stratigraphy. The oldest sedimentary rocks are Silurian, but the floor on which they rest is unknown, and the author states that it was probably fused up and incorporated in the granite which is described in the paper. The Silurian rocks may have been folded before the granite was erupted; in any case the granite produced a zone of contact-metamorphism, whilst almost all the Silurian rocks may be considered to be examples of regional metamorphism, though the agents producing the metamorphism were least active to the east of Bathurst, where the Silurian limestones are very little altered. An anticlinal was probably produced at the time of the granitic intrusion. After a time there was subsidence, but at first it need not have been very extensive, since the Devonian conglomerates, sandstones, and shelly limestones were probably deposited in a comparatively shallow sea. They contain *Lepidodendron australe.* At Rydal they abut against the uplifted Silurian rocks of the Bathurst area. At the end of Devonian times there appears to have been a long interval, during which both Silurian and Devonian rocks were greatly denuded, and the granite exposed in places. The Upper Carboniferous and Permian rocks were deposited in the Lithgow district, but it is doubtful if they ever extended to Bathurst. There is nothing to show what happened in this region during Mesozoic and early Tertiary times. The Hawkesbury Sandstone (probably Triassic) may have approached nearer to Bathurst than it does now. In late Tertiary times stream-deposits were formed on the granitic rocks, and afterwards covered with thick basaltic lava-flows, which have since undergone much denudation.

2. "The Geology of Matto Grosso (particularly of the region drained by the Upper Paraguay)." By J. W. Evans, D.Sc., LL.B., F.G.S.

The district includes a portion of the Brazilian hill-country, and also of the low-lying plains to the south-west.

The rocks principally dealt with are unfossiliferous, and of unknown age, except that they appear to be older than the Devonian. They may be classified as follows:—

5. Matto Shales. (Relations not shown.)
4. Rizama Sandstone. (Perhaps some unconformity.)
3. Curumbá and Arara Limestones. (Very marked unconformity.)
2. Cuyabá Slates. (Strong unconformity.)
1. Ancient crystalline rocks.

The Devonian and later rocks are briefly described.

3. "Notes on the Occurrence of Mammoth-remains in the Yukon District of Canada and in Alaska." By George M. Dawson, C.M.G., LL.D., F.R.S., F.G.S.

In this paper various recorded occurrences of Mammoth-remains are noted and discussed. The remains are abundant in, if not strictly confined to, the limits of a great unglaciated area in the north-western part of the North American continent; whilst within the area which was covered by the great ice-mass which the author has described as the Cordilleran glacier, remains of the Mammoth are either entirely wanting or are very scarce. At the time of the existence of the Mammoth, the North American and Asiatic land was continuous; for an elevation of the land sufficient to enable the Mammoth to reach those islands of the Behring Sea where these bones have been found would result in the obliteration of Behring Straits.

The bones occur, along the northern coast of Alaska, in a layer of clay resting on the somewhat impure "ground-ice formation," which gives indications of stratification; and above the clay is a peaty layer. The author considers this "ground-ice" was formed as a deposit when more continental conditions prevailed, by snow-fall on a region without the slopes necessary to produce moving glaciers. The Mammoth may be supposed to have passed between Asia and America at this time. At a later date, when Behring Straits were opened and the perennial accumulation of snow ceased on the lowlands, the clay was probably carried down from the highlands and deposited during the overflow of rivers. Over this land the Mammoth roamed, and wherever local areas of decay of ice arose, bogs would be produced which served as veritable sink-traps. The author considers it probable that the accumulation of "ground-ice" was coincident with the second (and latest) epoch of maximum glaciation, which was followed by an important subsidence in British Columbia.

CORRESPONDENCE.

THE RECENT GEOLOGICAL HISTORY OF THE ARCTIC LANDS.

In Sir Henry Howorth's article, bearing the above title, which appeared in the November Number of this MAGAZINE, he writes (at page 499), "so far as we can make out, the climate (of the Circumpolar Lands) has been becoming more and more severe in historic times, and that in the Pleistocene age, so far as we have evidence, the climate of the Polar area was more, and not less, temperate than now." . . . . . "This again is confirmed by such facts as the occurrence of the great sea-cows, which Steller discovered around Behring's Island, in a latitude far away from all their relatives and congeners. They are essentially animals which thrive under temperate or subtropical conditions, and this colony, so lately occurring in the North Pacific, seems to point clearly to the climate of that region having been recently milder."

Quoting from my paper on Fossil *Sirenia* (GEOL. MAG. 1885, p. 423), "Assuming, as I think we may, that the living *Sirenia* *belong exclusively to the tropical regions of the earth*, and that *Rhytina*, in its boreal home, was simply a surviving relic from the past, a sort of geological 'outlier,' we must conclude that the presence of about 12 genera and 27 species of fossil *Sirenia*, as widely distributed (over Europe and America) then, as the recent forms are (within the tropics) at the present day, *but with a range from the tropic of Cancer up to (nearly)* 60° *of north latitude*, attests the former northern extension of subtropical conditions of climate which must have prevailed over Europe, Asia, and North America in Tertiary times."

It seems to me that the only doubtful point is as to when and how long in Tertiary times this warmer condition of climate lasted. Nor must we omit to bear in mind that the survival of "Steller's sea-cow" (*Rhytina gigas*), down to 1780, around the shores of Behring and Copper Islands, in 55°–60° N. latitude, is very largely, if not wholly, due to the "Kuro-Sivo," or "Black River," *the Gulf-stream* of the Northern Pacific, which, by its warm waters, encourages the growth so far to the northward of those vast submarine meadows of succulent Algæ on which these Phytophagous Sirenians subsisted. Nor has the changing climate or want of food caused the elimination of this last survivor of Tertiary times, but the hand of Man the destroyer. The wide distribution of numerous species of *Sirenia* in Tertiary times over Europe and America is, however, a powerful argument in favour of the former higher temperature of our Northern hemisphere.

HENRY WOODWARD.

THE CARBON-CRUST ON FOSSIL PLANTS.

SIR,—It is well known that Fossil plants when found in sandstone are generally entirely covered with a thin layer of nearly pure carbon; in the case of Calamites, etc., in the Coal-measure sandstones the layer is often not more than about $\frac{1}{20}$ of an inch in thickness. It very readily falls away, and it is only in rare cases that it adheres to the sandstone cast. I should like to propose some questions concerning this carbonaceous covering to your readers. (1) Why is the whole of the carbonaceous residue in well-preserved fossils confined to the outside of the cast? (2) Does the carbonaceous layer represent the whole of the carbon of the tissue of the plant? (3) Why, in comparatively soft and little altered freestones, should the carbonaceous layer exhibit such a baked or charred appearance?

A. WILMORE.

WESLEYAN SCHOOLS, TRAWTEN, COLNE, LANCASHIRE,
November 8th, 1893.

OBITUARY.

JOHN HOOKE TAUNTON, M.INST.C.E., F.G.S.

EARLY in the present year[1] we lost by death Mr. John Hooke Taunton, M.Inst.C.E., F.G.S., of Stroud. Mr. Taunton had an intimate acquaintance with the water-bearing strata of the Cotteswold Hills, and furnished some valuable information to the Report of the Commissioners on Water Supply (1869). He was for many years local engineer to the Thames and Severn Canal Company, and also consulting engineer to the Stroud Local Board of Health. He contributed several papers to the Proceedings of the Cotteswold Naturalists' Club, of which he was an active member: among these were papers on the Hydrology of the Cotteswolds, on the Geology of the Sapperton Tunnel, on the Malmesbury Waterworks, and on the Dynamic Geology of Palestine.

THE REV. H. W. CROSSKEY, LL.D., F.G.S.

BORN 1826. DIED OCTOBER 1ST, 1893.

IN Dr. H. W. Crosskey we have to record the loss of one who was a most ardent student of Glacial Geology and the author of a valuable series of Reports on the Erratic blocks of this country, communicated during the past 20 years to the British Association. He paid much attention to the post-Tertiary deposits of the Clyde Valley, and was associated with David Robertson and Dr. G. S. Brady in describing the post-Tertiary Entomostraca in the Palæontographical Society's Volume for 1874. Whilst resident in Glasgow he contributed many papers to the Geological Society of Glasgow. He died at his residence, Edgbaston, Birmingham, Oct. 1st, 1893.

---

[1] January 31st, 1893.

INDEX.

ABBOTT, G., Was the Deposit of Flint and Chalk Contemporaneous? 275; The Relative Age of Flints, 477.
Abnormal Forms of *Spirifera lineata*, 249.
Abstracts of Papers read at British Association (Geology), 548.
Æpyornis, Upon, 572.
Affinities of *Anthracoptera* and of *Anthracomya*, 188.
——— ——— the Genus *Astrocœnia*, 378.
Africa, Contributions to the Geology of, 436.
——— Geological Sketch of Central East, 561.
Alps, On some Quartz-schists from the, 204.
American Tapir, Evolution of the, 391.
Analysis of the Fuller's Earth of Vrongoch, 160.
Anchisaurus, *Ceratosaurus*, and *Claosaurus*, 150.
Annals of British Geology, 134.
Annual General Meeting of the Geological Society, 180.
Anomœodus, On the Genus, 487.
——— *superbus*, A. S. Woodw., sp. nov., 489.
——— *Willetti*, A. S. Woodw., sp. nov., 489.
Antarctic Continent, The, 225.
Anthracite and Bituminous Coal-beds, 136.
Anthracoptera Fossil, 540.
Aptychopsis Williamsii, T. R. J. and H. W., sp. nov., 201.
Arabia Petræa, The Geological Features of, 44.
Archipelago, Note on the Tuscan, 272.
Arctic Lands, 495.
——— Recent Geological History of the, 575.
——— in the so-called Glacial Age, 302.
Armstrong, James, Obituary of, 94.
Arnold-Bemrose, H. H., on the Derbyshire Toadstone, 559.
Astrocœnia gibbosa, Tomes, from New South Wales, 379.
Athrodon crassus, A. S. Woodw., sp. nov., 435.
Athrodon intermedius, A. S. Woodw., sp. nov., 434.
——— *tenuis*, A. S. Woodw., sp. nov., 435.
Aveline, W. T., The St. Bees Sandstone, 87.

BACUP, New Species of *Cyclus* from, 28.
Bajocian of the Sherborne District, 375.
Ball, V., on the Volcanoes of Barren Island, 289.
Barren Island and Narcondam, Volcanoes of, 289.
Barrow, G., on Thermo-metamorphism, 238.
Bathurst, The Geology of, 573.
Bayfield, T. G., Obituary of, 240.
Bell, Dugald, Origin of certain Granite Boulders in the Clyde Valley, 138; Alleged Submergence of Britain during the Glacial Epoch, 333.
Bendigo Gold-field, 565.
Berthelot's Principle applied to Magmatic Concentration, 546.
Bertrand, M., The Mountains of Scotland, 118.
Biotite in the Crystalline Schists from the Binnenthal, 47.
Blake, J. F., Annals of British Geology, 134; The Shell-beds of Moel-Tryfaen, 267; on the Felsites and Conglomerates between Bethesda and Llanllyfni, 287.
Blanford, H. F., Obituary of, 190.
Bolivia, Palæozoic, Fossils from, 367.
Bolton, H., on the Occurrence of a Trilobite in the Skiddaw Slates, 29.
Bonney, T. G., Note on the Nufenenstock, 46; Greenstones and allied Hornblendic Schists from the Pennine Alps, 46; Biotite and Hornblende in Crystalline Schists from the Binnenthal, 47; on some Quartz Schists from the Alps, 204.
——— and Raisin, on the so-called Spilites of Jersey, 59: on the Variolite of the Lleyn, 86.
Boring at Willoughby, in Lincolnshire, 142.
Borings in East Lincolnshire, 329.
Boulders and Pebbles from the Glacial Drift, 189.

Brachiopoda of Minnesota, 421.
——— New Classifications of, 318.
Brehm, A. E., Marvels of Nature, 178.
Bridgewater District, Ontario, 47.
British Association for the Advancement of Science, 469, 548.
——— Earthquakes, 291.
——— British Geology, Annals of, 134.
——— Iron-ores, 372.
Brodie, P. B., Fish-remains in Green Marls of Warwickshire, 84; Eocene Tertiary Insects of the Isle of Wight, 538.
Bryozoa from the Inferior Oolite of Shipton Gorge, 285.
Buckman, S. S., Titles of Separate Copies of Scientific Papers, 140; The Bajocian of the Sherborne District, 375.
Burckhardt, R., on *Æpyornis*, 572.

CALAMITES, Notes on some Pennsylvanian, 85.
Calamostachys Binneyana, Schimp., 85.
Callaway, C., Origin of the Crystalline Schists, 286; Conversion of Chlorite into Biotite, 535.
Cambridge, Jurassic Rocks near, 40.
——— University, 48.
Cambrian in Wales, Base of the, 548.
Canada, Devonian Fishes of, 145, 262.
Candona subreniformis, T. R. Jones, sp. nov., 388.
——— *subovata*, T. R. Jones, sp. nov., 388.
Carbon-crust on Fossil Plants, 576.
Carboniferous Fossils of New South Wales, 80.
Carnivorous Dinosaur, from Peterborough, 238.
Catalogue of British Jurassic Gasteropoda, 38.
Cause of Crateriform Sand Dunes and Cwms, 323.
Cavern Researches, 327.
Cephalaspis Jexi, Traquair, sp. nov., 147.
Cestraciont Remains from the Green Marls, Warwickshire, 84.
Chapman, F., on Sheared Limestones from Ilfracombe, 100.
——— and Sherborn, on the Ostracoda of the Gault at Folkestone, 345.
Charlesworth, Edward, Obituary of, 526.
Charms, Fossils applied as, 246.
Cheilostomatous Bryozoa from the Middle Lias, 379.
? *Cheiracanthus costellatus*, Traquair, sp. nov., 146.
Choffat, P., on the Jurassic Fauna of Portugal, 371.
Claims of Priority, 288.
Clarke and Hall, Study of Palæozoic Brachiopoda, 134, 518.
Claypole, E. W., The Upper Devonian Fishes of Ohio, 443.
Clyde Valley, Granite Boulders in the, 138.
Conrad's Fossil shells of North America, 564.
Coal-measures, a new Palæoniscid Fish from the, 54.
——— Fossil Fish-remains of the, 72.
Cœlodus fimbriatus, A. S. Woodw., sp. nov., 491.
——— *inæquidens*, A. S. Woodw., sp. nov., 491.
Cole, G. A. J., Rocks of the Volcano of Rhobell Fawr, 337.
Collins, J. H., Geological Notes on the Bridgewater District of Ontario, 47.
Concealed Ridge of pre-Carboniferous Rocks at Netherseal, 552.
Concentric Lamination amongst Pebbles on Northam Ridge, 477, 526.
Conflict between Geology and Physics, 87
Contemporaneity of Chalk and Flint, 275.
Cooke, J. H., The Marls and Clays of the Maltese Islands, 45; *Ursus ferox* in the Pleistocene of Malta, 67; Maltese Cave Exploration, 144; Concretionary Masses of Flint and Chert in Maltese Limestones, 157.
Coryphodon, Restoration of, 481.
Cossmann, M., Revision of the Oligocene Fauna of Etampes, 424.
Crane, Agnes, New Classification of the Brachiopoda, 318.
Cranial Osteology of *Lepidotus* and *Dapedius*, 413.
Cretaceous Pycnodont Fishes, 433, 487.
Crosskey, Rev. H. W., Obituary of, 576.
Crustacea, A History of, 324.
Cybium Bleekeri, On a Cranium of, 326.
Cyclus, from the Coal-measures, 28.
——— *Scotti*, H. Woodw., sp. nov., 28.
——— *Woodwardi*, Reed, sp. nov. ? 65.
Cythere lineatopunctata, Chap. and Sherb., sp. nov., 348.
——— *monticula*, T. R. J., sp. nov., 389.
——— ? *spinifera*, Chap. and Sherb., sp. nov., 348.
Cythereis excavata, Chap. and Sherb., sp. nov., 348.
——— *rudispinata*, Chap. and Sherb., sp. nov., 348.
——— *triplica*, Chap. and Sherb., sp. nov., 348.

Cytheridea rotundata, Chap. and Sherb., sp. nov., 349.
——— *tenuis*, T. R. J., sp. nov., 390.
——— *truncata*, T. R. J., sp. nov., 390.
Cytherideis æqualis, T. R. J., sp. nov., 390.
——— *impressa*, T. R. J., sp. nov., 391.
Cytheropteron Folkestoniensis, Chap. and Sherb., sp. nov., 349.

DARTMOOR, Notes on, 329.
Davies, Thomas, Obituary of, 69.
Davis, James William, Fossil Fish-remains of the Coal-measures, 72.
——— Obituary of, 427.
Davison, C., on the British Earthquakes of 1892, 291; Note on the Quetta Earthquake, 356; on the Growth of Lake Geneva, 454.
Dawson, G. M., Occurrence of Mammoth-remains in the Yukon district of Canada, 574.
Deeley, R. M., on the Glacial Succession, 31.
Dentition of *Myliobatis* from the Tertiary of Egypt, 414.
Derbyshire Toadstone, 559.
Devonian Fishes of Campbelltown and Scaumenac Bay, 145, 262.
——— Rocks, Folds and Faults, in the, 3.
Dinosaurian Teeth from Aylesbury, 378.
——— Vertebra from the Wealden of Hastings, 84.
Discites from the Lower Carboniferous of Ireland, 251.
——— *Hibernicus*, Ford and Crick, sp. nov., 253.
Disseminated Silica in Chalk considered in Relation to Flints, 541.
Dunlop, A., on Raised Beaches at a High Level in Jersey, 375.
Dunn's Bendigo Gold-field, 565.
Dwindling and Disappearance of Limestones, 285.
Dykes of Arran, 376.
———Hope, Idaho, The Study of the, 379.

EARLE, C., The Evolution of the American Tapir, 391
Earthquake, Note on the Quetta, 356.
Earthquakes, On British, 291.
Elgin Sandstones, New Reptiles from the, 173.
Eminent Living Geologists, 1, 241.
Emmons, H., on the Petrography of the Island of Capraja, 86.
Engadine Lakes, On the Origin of the, 448.
Eocene Tertiary Insects of the Isle of Wight, 538.
Eskdale Drift, 9.
Estheria striata, var. *Muensteriana*, T. R. J., nov., 530.
——— *Reinachii*, T. R. J., sp. nov., 531.
——— *Geinitzii*, T. R. J., sp. nov., 531.
——— ——— var. *Grebeana*, T. R. J., nov., 532.
Etampes, Marine Oligocene Fauna of, 424.
Etheridge, R., Jun., Monograph of Carboniferous Invertebrata, 80.
Evans, J. W., The Geology of Matto Grosso, 574.
Excursions around Bath, 330.
Extinct Monsters, 41.

FELSITES and Conglomerates in North Wales, 289.
Fisher, O., on the Thickness of Marine Deposits, 255.
Fishes of Ohio, The Upper Devonian, 443.
Fish-remains from the Coal-measures of Britain, 72.
Flint and Chalk, 275.
——— Chert in Maltese Limestone, 157.
—— The Relative Age of, 315, 477.
Flints, Silica in Chalk considered in Relation to, 541.
Florida, Contributions to the Tertiary Flora of, 472.
Folds and Faults in Devonian Rocks, 3.
Folkestone, On the Ostracoda of the Gault at, 345.
Foord, A. H., Claims of Priority, 288.
——— and Crick, on a New Species of *Discites* from Ireland, 251.
Foraminiferal Limestone from the Grenadine Islands, 270.
Forbes, H. O., The Chatham Islands and their Relation to an Antarctic Continent, 225.
Fossils applied as Charms or Ornaments, 246.
Fossil *Phyllopoda* of the Palæozoic Rocks, 529.
Fossil-remains from Samos, 69.
—— Reptilia, Classification of the, 360.
—— Sponges, 524.
Fox, Howard, Notes on Coast Sections at the Lizard, 136; on a Radiolarian Chert from Mullion Island, 137; Radiolarian Cherts of Cornwall, 558.
Fox-Strangways, E., on the Jurassic Rocks of Britain, 415.
Fraas, E., on the Irpfel Cavern, 327.
Frederick, G. C., Geological Remarks on the New Hebrides, 189.
Fritsch, Anton, Fauna of Gas-coal, 175.
Fuller's Earth of Vrongoch, Analysis of, 160.

GAS-COAL, Fauna of the, 175.
Gasteropoda, British Jurassic, 38.
Geological Development of the Mammalia, 401, 455, 501.
——— History of Arctic Lands, 495.
——— Remarks on certain Islands in the New Hebrides, 189.
——— Society of Glasgow, 138, 333.
——— ——— London, 44, 84, 135, 180, 238, 284, 328, 375, 573.
——— Survey, 415.
——— ——— of United States, 523.
——— Time, Measurement of, 97.
Geologists' Association, 330.
Geologists, Eminent Living, 1, 241.
Geology of Africa, 436.
——— of the District West of Caermarthen, 138.
——— of the Southern Transvaal, 521.
——— and Palæontology of South America, 367.
——— and Palæontology of Queensland, 279.
——— Text Book of Comparative, 361.
Gibson, Walcot, Geological Sketch of Central East Africa, 561.
Glacial Action in Iceland, 426.
——— Age, Arctic Lands in the so-called, 302.
——— Geology, 93.
——— ——— and Eskdale Drift, 9.
——— ——— Old and New, 35.
——— Submergence of the British Islands, 277.
——— Succession, 31.
——— Period, Submergence of the British Isles during the, 104.
Glacier Observations, 349.
Gosselet, M., Phosphate Beds in the North of France, 563.
Granite, 41.
"Greenstones" from the Pennine Alps, 46.
Grenadine Islands, Foraminiferal Limestone from the, 270.
Gresley, W. S., Notes on some Pennsylvanian Calamites, 85; Anthracite and Bituminous Coal-beds, 136.
Growth of the Indian Peninsula, 309.
——— Lake Geneva, Notes on the, 454.

HALL and Clarke, Introduction to the Study of Palæozoic Brachiopods, 130; on Palæozic Brachiopods, 518.
——— Marshall, Glacier Observations, 349.
Hardy, J. D., on Glacial Submergence, 277.
Harker, Alfred, Scandinavian Rocks in the English Boulder-clays, 140; Metamorphic Rocks around the Shap Granite, 287; Magmatic Concentration, 546.
Harlé, E., on Cavern and Pleistocene Deposits, South of France, 327.
Harris, G. D., Republication of Conrad's Fossil Shells of North America, 564.
Hicks, Henry, Folds and Faults in the Devonian Rocks, 3; The Mammoth and the Glacial Drift, 90, 139; The Pre-Cambrian Rocks of Wales, 396; on the Base of the Cambrian in Wales, 548.
——— T., on *Calamostachys Binneyana*, Schimp, 85.
Higgins, Rev. H. H., Obituary of, 380.
Hind, Wheelton, on the Affinities of *Anthracoptera* and of *Anthracomya*, 188; Note on *Myalina crassa*, 514; Slab of Shale above the Kinder Scout Grit, 540.
Hinde, G. J., on a new Hexactinellid Sponge from Quebec, 56; Note on a Radiolarian Rock from Port Darwin, 137.
Hobson, Bernard, Granite, 91.
Holm, Gerhard, on the Hyolithidæ and Conulariidæ of Sweden, 368.
Homfray, David, Obituary of, 479.
Hornblende-Pikrite from Wicklow, 550.
Howell, F. W. W., Glacial Action in Iceland, 426.
Howorth, Sir H. H., The True Horizon of the Mammoth, 20, 161, 355; The Mammoth and the Glacial Drift, 89; Condition of the Arctic Lands in the so-called Glacial Age, 302; Recent Geological History of Arctic Lands, 495.
How the Waters of the Ocean became Salt, 165.
Hudleston, W. H., Catalogue of Jurassic Gasteropoda, 38.
Hull, E., on the Geological Features of Arabia, Petræa, and Palestine, 44; Submergence of the British Isles during the Glacial Period, 104; How the Waters of the Ocean became Salt, 165; Discovery of a Concealed Ridge of Pre-Carboniferous Rocks at Netherseal, 552; The Water-bearing Capacity of the New Red at Nottingham, 553.
Hunt, A. R., The Rocks of South Devon, 139; The Pebble-ridge at Westward Ho, 477; Concentric Lamination amongst the Pebbles on Northam Ridge, 526.

Hutchinson, H. N., Extinct Monsters, 41.
Hutton, F. W., on a New Plesiosaur from New Zealand, 378.
Hyolithes and *Conularia*, 368.

IDDINGS, J. P., on the Volcanoes of Wyoming, 559.
Igneous Rocks at Barnavave, Carlingford, 551.
Indian Peninsula, The Growth of the, 309.
Intrusive Sheets of Diabase near Bassenthwaite, 378.
Ireland, New Species of *Discites* from, 251.
Iron-ore in the Lias of Raasay, 492.
Irving, A., Keuper Formation of Devon, 44; Selenology, 48; post-Eocene Surface-changes in London Basin, 211.
Isle of Wight, Eocene Tertiary Insects of the, 538.

JACK and Etheridge, Geology of Queensland and New Guinea, 279.
Japan, Seismological Society of, 515.
Jersey, On the so-called Spilites of, 59.
Jervis, Chev. W. P., Volcano of Mergellina, 235.
Jones, Prof. T. R., Biographical Notice of, 1; on Some Palæozoic Ostracoda from Westmoreland, 248; on Some Palæozoic Ostracoda from Girvan, 285; on Some Fossil Ostracoda from Wyoming and Utah, 385.
——— and Woodward, on Palæozoic Phyllopods, etc., 198; The Fossil *Phyllopoda* of the Palæozoic Rocks, 529.
Judd, J. W., Tertiary Granite in the Gabbro of the Cuilin Hills, 135; on Composite Dykes in Arran, 376.
Jukes-Browne, A. J., The Mammoth of the Glacial Drift, 141; A Boring at Willoughby in Lincolnshire, 142, 329; Foraminiferal Limestone from the Grenadine Islands, 270; The Relative Age of Flints, 315; Disseminated Silica in Chalk considered in Relation to Flints, 541.
Jurassic Fauna of Portugal, 371.
——— Rocks, near Cambridge, 40.
——— ——— of Britain, 415.

KAYSER, E., Text Book of Comparative Geology, 361.
Kendall, J. D., Iron-ores of Great Britain and Ireland, 372.
Keuper Formation in Devon, 44.
Kinder Scout Grit, Slab of Shale from above the, 540.
King, F. H., Fluctuations of Level of Groundwater in Wisconsin, 568.

LAKE, Philip, The Growth of the Indian Peninsula, 309; Llandovery and Associated Rocks near Corwen, 328.
Lake Geneva, Note on the Growth of, 454.
——— Tanganyika, The Rise and Fall of, 379.
Lakes of Zurich and Wallen, 222.
Lemuroid Mammals from Madagascar, 336.
Lepontine Alps, 46.
Lincolnshire, A Remarkable Spring in, 96.
Lizard, Coast-Sections at the, 136.
London Basin, post-Eocene Surface-changes in the, 211.
Lydekker, R., on a Suropodous Dinosaurian Vertebra from Hastings, 48; Jaw of a Carnivorous Dinosaur from Peterborough, 238; Mammalian Incisor from Hastings, 238; Dinosaurian Teeth from Aylesbury, 378.

MADAGASCAR, Discovery of a Secondary Reptile in, 194.
Madsen, Victor, Scandinavian Boulders at Cromer, 85.
Magmatic Concentrations, Berthelot's Principle applied to, 546.
Major, C. J. Forsyth, on the Fossil-remains from Samos, 69; on *Megaladapis madagascariensis*, 336.
Maltese Cave-exploration, 144.
——— Islands, Marls and Clays of, 45.
——— Limestones, Flint and Chert in, 157.
Malvern Crystallines, 92.
Mammalia, Geological Development of the, 401, 455, 501.
Mammalian Incisor from the Wealden of Hastings, 238.
Mammoth and the Glacial Drift, 89, 90, 139, 141.
——— Remains in the Yukon District of Canada and in Alaska, 574.
——— The True Horizon of the, 20, 107, 161, 334, 353.
Marine Deposits, On the Thickness and Expansion of, 255.

Marsh, O. C., Restoration of Dinosaurs (*Anchisaurus*, *Ceratosaurus*, and *Claosaurus*), 150; Restoration of *Mastodon Americanus*, Cuvier, 164; Restoration of *Coryphodon*, 481.
Marvels of Nature, 178.
Mastodon Americanus, Restoration of, 164.
Matto Grosso, The Geology of, 574.
McMahon, C. A., Notes on Dartmoor, 329.
Measurement of Geological Time, 97.
Mergellina, Submerged Volcano of, 235.
Mesozoic Ganoid Fishes, 413.
Metacypris consobrina, T. R. Jones, sp. nov., 388.
——— *cuneiformis*, T. R. Jones, sp. nov., 389.
——— *simplex*, T. R. Jones, sp. nov., 389.
——— *subcordata*, T. R. Jones, sp. nov., 388.
Metamorphic Rocks around the Shap Granite, 287.
Meteoric Stone found at Makariwa, 130.
Microscopic Structure of the Wenlock Limestone, 188.
Minnesota, Geological Survey, 421.
Moel Tryfaen, The Shell-beds of, 267.
Molluscan Remains lately discovered in the English Keuper, 557.
Monckton, H. W., Boulders and Pebbles from the Glacial Drift, 189.
Monograptus priodon, Skeleton of, 551.
Monsters, Extinct, 41.
Mountains of Scotland, 118.
Murchison Gold Field of Western Australia, 288, 412.
Muscovite-biotite-gneiss in the Southern Highlands, 238.
Myalina crassa, Note on, 514.
Myliobatis, on the Dentition of an Extinct Species of, 414.
Myriolepis Hibernicus, Traquair, sp. nov., 54.

NEWBERRY, Prof. J. S., Obituary of, 94.
New Guinea, Geology and Palæontology of, 279.
—— York, Palæontology of, 518.
—— South Wales, Carboniferous Fossils of, 80.
Newton, E. T., New Reptiles from the Elgin Sandstone, 173; Reptilia of the British Trias, 555.
——— R. B., a Secondary Reptile from Madagascar, 194; Molluscan Remains lately discovered in the English Keuper, 557.
Novák, Dr. Ottomar, Obituary of, 190.

OBITUARY of Professor Sir Richard Owen, 48, 49; James Armstrong, 94; Prof. J. S. Newberry, 94; Thomas Davies, 96; Prof. J. O. Westwood, 143; Martin Simpson, 144; Dr. Ottomar Novák, 190; Henry Francis Blanford, 191; Thomas Gabriel Bayfield, 240; Rev. H. H. Higgins, 380; James William Davis, 427; David Homfray, 479; G. W. Shrubsole, 480; Edward Charlesworth, 526; J. H. Taunton, 576; Rev. H. W. Crosskey, 576.

Ohio, The Upper Devonian Fishes of, 443.
Old and New Glacial Geology, 35.
Oligocene Fauna of Etampes, 424.
Oolitic Limestones with Sheared Structure from Ilfracombe, 100.
Origin of Crystalline Schists, 286.
——— the Engadine Lakes, 448.
Ostracoda of the Gault at Folkestone, 345.
——— from S.W. Wyoming, 385.
Owen, Prof. Sir Richard, Obituary of, 48, 49.

PALÆONISCID Fish from Kilkenny, 54.
Palæontology, Elementary, 570.
Palæontology of New York, 518.
Palæosaccus, Hinde, gen. nov., 57.
——— *Dawsoni*, Hinde, sp. nov., 58.
Palæospondylus Gunni, A Further Description of, 471.
Palæospongiologie by Dr. Hermann Rauff, 524.
Palæozoic Brachiopoda, 130.
——— Ostracoda from Westmoreland, 284.
——— ——— from Girvan, 285.
——— Phyllopods and other Fossils, 198.
Palæozoic Rocks, the Fossil *Phyllopoda* of the, 529.
Pebble-Ridge at Westward Ho, 477.
Peltocaris Salteriana, T. R. Jones and H. Woodw., sp. nov., 199.
Penning, W. H., Geology of the Southern Transvaal, 521.
Perlitic Quartz Grains in Rhyolite, 550.
Permian Fauna of Bohemia, 175.
Petrography of the Island of Capraja, 86.
Petrography, 565.
Philippi, R. A., on the Fossil Bones of Ulloma, 328.
Phosphate Beds in the North of France, 563.
Plateau-gravels South of Reading, 190.

PLE

Pleistocene of Malta, Occurrence of *Ursus ferox* in the, 66.
Post-Eocene Surface Changes in the London Basin, 211.
Postlethwaite, J., on an Intrusive Sheet of Diabase near Bassenthwaite, 378.
Post-Tertiary Vertebrate Remains from Madagascar, 194.
Potamocypris affinis, T. R. Jones, sp. nov., 387.
Pre-Cambrian Rocks of Wales, 396.
Preller, C. S. Du Riche, Note on the Lakes of Zurich and Wallen, 222; Notes on the Tuscan Archipelago, 272; On the Origin of the Engadine Lakes, 448.
Preston, S. T., Conflict between Geology and Physics, 87.
Prestwich, Prof. J., Biographical Notice of, 241.
Pycnodont Skull, On the Structure of the, 487.

QUARTZ-SCHISTS from the Alps, 204.
Quaternary and ? Tertiary Deposits in Texas, 92.
Quebec Group, New Hexactinellid Sponge from the, 56.
Quetta Earthquake, The, 356.

RAASAY, Iron-ore in the Lias of, 493.
Radiolarian Chert from Mullion Island, 137.
——— of Cornwall, 558.
——— Rocks from Fanny Bay, 137.
Railway Danger, An Unfamiliar, 380.
Raised Beaches of Jersey, 375.
Raisin, Miss C. A., Contributions to the Geology of Africa, 436.
——— and Bonney, on the so-called Spilites of Jersey, 59; on the Variolite of the Lleyn, 86.
Rauff, H., on Fossil Sponges, 524.
Reade, T. M., on the Eskdale Drift, 9; Glacial Geology, 35; Measurement of Geological Time, 98.
Reed, F. R. Cowper, Woodwardian Museum Notes, 64, 249.
Relative Age of Flints, 315.
Restoration of *Coryphodon*, 481.
——— of Dinosaurs, *Anchisaurus*, of *Ceratosaurus* and *Claosaurus*, 150.
——— of *Mastodon Americanus*, Cuvier, 164.
Reptiles from the Elgin Sandstone, 173.
Roberts, T., Jurassic Rocks in the Neighbourhood of Cambridge, 40; Geology of the District West of Caermarthen, 138.
Rock Metamorphism, 535.
Rocks in the Neighbourhood of Corwen, 328.
——— of South Devon, 139.
——— of the Volcano of Rhobell Fawr, 337.
Ross, W. J. C., The Geology of Bathurst, 573.
Rutley, F., Dwindling and Disappearance of Limestones, 285.

STE

SALT, How the waters of the Ocean became, 165.
Samos, On the Fossil-remains from, 69.
Sand-Dunes and Cwms, Cause of Crateriform, 323.
Sanford, Gerald P., Fuller's Earth of Vrongoch, 160.
Scandinavian Boulders at Cromer, 85.
——— Rocks in English Boulder-clay, 140.
Scientific Papers, Titles of Separate Copies of, 140.
Scotland, The Mountains of, 118.
Seeley, H. G., Structure, Organization and Classification of the Fossil Reptilia, 360.
Seismological Society of Japan, 515.
Selenology, 48.
Sheared Limestones from Ilfracombe, 100.
Shell-beds of Moel Tryfaen, 267.
Sherborn and Chapman, on the Ostracoda of the Gault at Folkestone, 345.
Shone, W., Subterranean Erosion, 142; Cause of Crateriform Sand-Dunes and Cwms, 323.
Shrubsole, O. A., on the Plateau-Gravel of Reading, 190.
——— G. W., Obituary of 480.
Sieger, R., The Rise and Fall of Lake Tanganyika, 379.
Simpson, Martin, Obituary of, 144.
Skiddaw Slates, Occurrence of a Trilobite in the, 29.
Sollas, J. W., Origin of Varieties of Igneous Rocks at Barnavave, Carlingford, 551; on the Minute Structure of the Skeleton of *Monograptus priodon*, 551.
Spilites of Jersey, So-called, 59.
Sponge, A New Genus and Species of, from Canada, 56.
St. Bees Sandstone, 87.
Stebbing, Rev. T. R. R., a History of Crustacea, 324.
Steneosaurus Baroni, R. B. Newton, sp. nov., 194.

Stirrup, Mark, The True Horizon of the Mammoth, 107, 334.
Storms, R., on a Cranium of *Cybium Bleekeri*, 326.
Structure and Classification of the Fossil Reptilia, 360.
Submergence of the British Isles, 104, 277.
Subterranean Erosion, 142.

TAPIR, Evolution of the American, 391.
Taunton, J. H., Obituary of, 576.
Teall, J. J. H., A Coast Section at the Lizard, 136; on a Radiolarian Chert from Mullion Island, 137.
Tertiary Flora of Florida, 472.
——— Granite in the Gabbro of the Cuilin Hills, Skye, 135.
Text Book of Comparative Geology, 361.
Thickness, Expansion and Elevation of Marine Deposits, 255.
Titles of Papers read before Section (C), Geology, 469, 548.
Tomes, R. F., Affinities of the Genus *Astrocœnia*, 378; a New Genus of *Madreporaria*, 379.
Traquair, R. H., on a New Palæoniscid Fish, 54; Devonian Fishes of Campbelltown, etc., 145, 262; a Further Description of *Palæospondylus Gunni*, 471.
Trias, On the Reptilia of the British, 555.
Trilobite in the Skiddaw Slates, 29.
True Horizon of the Mammoth, 20, 107, 161, 334, 353.
Transvaal, Geology of the Southern, 521.
Tuscan Archipelago, 272.
Type Fossils in the Woodwardian Museum, 111.

ULLOMA, Preliminary Notices of the Fossil Bones of, 328.
Ulrich, A., Palæozoic Fossils of Bolivia, 367.
——— G. H. F., on a Meteoric Stone from New Zealand, 130.
United States Geological Survey, Publications of, 523.
Ursus ferox, in the Pleistocene of Malta, 67.
Utah, Fossil Ostracoda from Wyoming, etc., 385.

VARIOLITE of the Lleyn and Associated Volcanic Rocks, 86.
Volcanoes of Barren Island, 289.
Volcano of Mergellina, 235.
——— of Rhobell Fawr, The Rocks of the, 337.

WALES, The pre-Cambrian Rocks of, 396.
Walford, E. A., on some Bryozoa from the Inferior Oolite of Shipton Gorge, 285; on Cheilostomatous Bryozoa from the Middle Lias, 379.
Water-bearing Capacity of the New Red Sandstone at Nottingham, 553.
Watts, W. W., Note on a Hornblende-Pikrite from Wicklow, 550; Note on the Perlitic Quartz Grains in Rhyolite, 550.
Wealden of Hastings, Dinosaurian Vertebra from the, 84.
Western Australia, 288, 412.
Westwood, Prof. J. O., Obituary of, 143.
Wethered, E., Microscopic Structure of the Wenlock Limestone, 188.
Wilmore, A., The Carbon-crust on Fossil Plants, 576.
Winchell and Schuchert, on Lower Lias Brachiopoda, 421.
Wisconsin, Fluctuations in the level of Ground-water, 568.
Wood, H. R., Study of the Dykes of Hope, Idaho, 379.
Woods, H., Type Fossils in the Woodwardian Museum, 111; Elementary Palæontology, 570.
Woodward, A. S., on the Cranial Osteology of *Lepidotus* and *Dapedius*, 413; on the Dentition of an Extinct species of *Myliobatis*, 414; Cretaceous Pycnodont Fishes, 433, 487.
——— ——— H., on a New British Species of *Cyclus*, 28; on Fossils applied as Charms or Ornaments, 246; The Recent Geological History of Arctic lands, 575.
——— ——— H. B., on a Bed of Oolitic Iron-ore in Raasay, 493.
——— ——— H. P., Report on the Murchison Gold-fields, 288, 412.
Woodwardian Museum Notes, 64, 249.
Wyoming, The Dissected Volcano of Crandall Basin, 559.

ZIRKEL'S Petrography, 565.
Zittel, Karl A. von, The Development of the Mammalia, 401, 455, 501.
Zurich and Wallen, Note on the Lakes of, 222.

STEPHEN AUSTIN AND SONS, PRINTERS, HERTFORD.

926

INSTITUTION LIBRARIES
3 9088 01366 6813